Outdoor recreation and the multiple use management of natural resources

van der Ploeg, S.W.F.

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OUTDOOR RECREATION and the MULTIPLE USE MANAGEMENT of NATURAL RESOURCES

ACADEMISCH PROEFSCHRIFT

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door

SIMON WILLEBRORD FLORIS VAN DER PLOEG

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Promotoren: prof. dr. L. Vlijm
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dr. A.J. Wiggers

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CONTENTS

VOORWOORD

"Functies van de natuur": dat was het thema voor dit proefschrift en dat is het nog steeds. Daarbij gaat het over het gebruik dat mensen en de maatschappij kunnen maken van goederen en diensten die door de natuur worden geleverd. Het onderzoek naar met name de maatschappelijke waardering van die door de natuur vervulde functies, uitgevoerd door het Instituut voor Milieuvraagstukken aan de Vrije Universiteit, is in 1971 gestart. Uitgangspunt vormde destijds Hueting's (1970) publicatie: "Wat is natuur ons waard?". In 1975 werd een fase van merendeels theoretische verkenning afgesloten met de publicatie "Functies van de natuur: een economisch-ecologische analyse" (Bouma & Van der Ploeg, 1975). Deze multidisciplinaire aanpak mondde uit in een "Geïntegreerd Milieumodel" (Arntzen e.a., 1981), en leidde tot het uitspreken van de verwachting dat het "functie-onderzoek" zou worden gericht op functie-interacties en een modelmatige benadering daarvan. "Wellicht kan dan in 1991 het tweede decennium van het IVM worden gevierd met een meer kwantitatief onderbouwde bijdrage aan de literatuur omtrent de natuurfuncties", schreven we destijds (Van der Ploeg & Braat, 1982). Het voorliggende proefschrift is een poging daartoe, en een proefschrift van L.C. Braat over de modelmatige benadering van functie-interacties is thans in voorbereiding.
Van meet af aan heeft openluchtrecreatie als één van de gebruiksvormen van natuurgebieden een grote rol gespeeld in het functie-onderzoek. Met name in het vorige decennium kwam de vraag op of deze ogenschijnlijk "onschadelijke" gebruiksvorm wellicht een veel grotere - en desastreuzere - invloed op natuurgebieden zou kunnen uitoefenen dan voorheen werd aangenomen. Dit proefschrift is in zekere mate bedoeld als een synthese van onze bevindingen van de afgelopen achttien jaar, in relatie tot de bevindingen van vele anderen in Nederland en daarbuiten. Waren de aanvankelijke onderzoekingen gericht op de wetenschappelijke analyse van het probleem van de interactie tussen recreatie en natuurbehoud, thans is die analyse - ook omdat de stand van de kennis langzaamaan substantieel is geworden - geplaatst in het licht van beheersmogelijkheden voor meervoudig gebruikte natuurgebieden.

Lang bezig zijn met een onderwerp impliceert een lange lijst van personen waaraan ik mijn dank wil betuigen voor hun toezicht, hun medewerking, hun advies, hun steun. Mijn leermeester professor Vlijm dank ik voor zijn zeer inspirerende leiderschap en voor zijn mildheid. Mijn voormalige directeur professor Lambooy ben ik erkentelijk voor zijn stimulerende optimisme. Mijn huidige directeur professor Opschoor dank ik voor zijn

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Velen weten het: mijn werk kan niet zonder studenten. Zij hebben een gegevensbasis gecreëerd waarvan dit proefschrift slechts enkele stenen kan oplichten. Maar ook hun wederwoord in discussies over het onderzoek is voor mij zeer stimulerend geweest. In chronologische volgorde zeg ik met name dank aan Ad Littel, Koos Boomsma, Leon Braat, Aart Vermeulen, Kees Schotten, Frans Vera, Hans ten Cate, Hans Rhebergen, Tonnie Rozijn, Herman de Jong, Peter Visser en Georgette Leltz. Dat ik hier namen van anderen niet noem zegt meer over het gewenste volume van dit boek dan over hun prestaties.
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Voorts gaat mijn dank uit naar vrienden/collega's buiten het IVM die waardevolle bijdragen hebben geleverd: Walter van Wingerden, Ab Kessler, Eric Duffey, Mike Liddle, Neil Bayfield, Frank Saris en Kees Kwakernaak.
Niets was er echter van gekomen als niet Doety, Jan en Frank het voor lief hadden genomen dat hun huisgenoot gedurende lange tijd wel erg "niet thuis" gaf. Ook ik ben niet aan die onwenselijke situatie ontkomen, en ik ben er dankbaar voor dat het toch allemaal kon.
Ik ben het Instituut voor Milieuvraagstukken, en daarmede de Vrije Universiteit, zeer erkentelijk voor alle (letterlijke en figuurlijke) ruimte en ondersteuning die mij is geboden om dit onderzoek te verrichten.

Ik draag dit boek op aan mijn overleden vader die, net als ik, de grenzen van zijn wetenschap met genoegen overschreed. Mijn onderwerp benadert qua breedheid niet het thema voor het door hem beoogde proefschrift ("Het gesprek"), maar ik denk dat hij mijn keuze zou hebben gewaardeerd.

Amsterdam, juli 1989
Floris van der Ploeg

1. INTRODUCTION

Suppose you are in charge of the management of a coastal sand dune area near to a million-inhabited urban zone. Your area supplies an increasing volume of drinking water to the inhabitants and also serves them for informal outdoor recreation. Nature conservationist lobbies complain that the dune area becomes increasingly spoilt by all kinds of human interference. Recreationists complain about fencing off the waterworks areas and about shortage of parking lots. Moreover, your management budget has hardly been sufficient in the last three years and the responsible regional authority is aware of that.
Now what would you do? You cannot cut on water-supply; an increased infiltration of polluted water would spoil the nature of the area even more. Neglecting either recreationists' or conservationists' interests would probably induce questions from the regional and local politicians. There is hardly money for investments. Cutting trees in your area would only be marginally profitable, and how to manage the harvested sites? Perhaps you would bet on incidental management on-the-spot, hoping that another political event would divert attention from your problems. Anyhow you would be left with the uncertain feeling that conflicting claims cannot be managed without sufficient budget and sufficient expert knowledge about what happens and why.

Situations like in the above example occur often and everywhere. Many resources on our planet are being used for different purposes simultaneously or consecutively. Often the more profitable use forms (in terms of economic return or political success) get most support, both from the politician and from the manager. Often the manager is aware of long-term deficiencies of his area as a result of short-term political preferences. Often he also experiences a thwarting of local interests being overruled by regional or even national priorities. The inevitable result of policy-compliant management is the suffering of "less profitable" aims like nature conservation from poor protection and negligent care.
On the world's scale, these problems have been drawn into focal attention by the publication of the World Conservation Strategy (IUCN, 1980), emphasizing sustainable use of natural resources by mankind in order to achieve sustainable development of the biosphere as a whole. This strategy is to be realized at the international and the national level. Also

the WCED report on sustainable development ("Our Common Future"; WCED, 1987) emphasizes this dependency of development on a sustained functioning of ecosystems on a global scale. Perhaps even more frequently, however, problems of conflicting use of natural resources appear in a local or a regional context.
The Netherlands, one of the most densely populated countries on earth, have faced a continuing series of resource use problems during the last 100 years. In comparison to apparent issues like the pollution of air, water and soil, rationalization of agricultural land use and increasing occupation by urban zones and transport networks, problems like impacts of outdoor recreation, relative desiccation of soils by water extraction and combined impacts of several human activities on nature conservation efforts are often treated as "luxury problems" (cf. De Boer *et al.*, 1983). Nonetheless such problems have become more and more relevant in small countries that cannot do without trying to compromise conflicting land use forms.

Before setting out the scope of this book, let us look in somewhat more detail at basic notions of the foregoing. First, what is exactly meant by "use of natural resources"? Second, how does nature conservation relate to use of natural resources? Third, what are the basic conflicts between nature conservation and land use forms like outdoor recreation?

Use of natural resources

Consider the coastal dune area again. At present it is used for sea defence, water purification and extraction, outdoor recreation, timber production and sand extraction. In the past it has been used for military purposes, for grazing, and as arable land. Parts of it are occupied by buildings (houses, parts of factories) and roads. In some parts scientific research is done; it also serves educational purposes. In summer people collect fruits, in autumn there is some hunting. Fourteen possibilities to use one and the same area. Still another would be: to use parts of the area as a refuge for plants and animals in their own right of living. It is up to policy-makers and managers to achieve a multiple use configuration for such an area that reflects public and private goals.

Natural resources are considered here to be goods or services to human beings delivered by nature directly, i.e. without being changed in some production process. Thus timber is a natural resource, while a wooden table is not; birds are a natural resource (e.g. for birdwatchers) but the Peterson field guide to them is not. After removal from their natural settings, resources are often called natural resource commodities (Howe, 1979).

The word "delivered" has to be understood in two ways. First, as a factual transition to the consumer (or producer), as in the case of timber. We may call this *extractive* use of the resource (Krutilla & Fisher, 1975). Second, in terms of experience, as in the case of birdwatching. We may call this non-extractive use.

Natural resources are part of, and are produced by *resource ecosystems* (Spurr, 1969; another term, used by Bouma & Van der Ploeg, 1975, is "physical resource complex"). This is easy to see for organisms like trees (timber) but it also partly holds for fossil fuels and minerals as, by definition, all matter and energy is or has been part of an ecosystem (only deep layers of minerals might be called part of a natural *geo*system).

The resource ecosystem thus contains separate natural resources. Moreover, the resource ecosystem may be part of an *area* containing different ecosystems. Such a natural area as a whole may be a resource for recreationists ("Let's go to the Yellowstone Park" instead of "Let's go to the forests of Yellowstone"), apart from the fact that it may be a resource in terms of capital for a private owner.

Even in our era of almost infinite technological possibilities we cannot (yet?) do without using natural resources. They serve basic needs (food, shelter, heating) of an increasing human population, and also contribute to perhaps less vital but still important other needs (comfort, pleasure; defence; curiosity). The question is not: "can natural resources satisfy many of our needs?", because to a large extent they can indeed, but: "are natural resources sufficient to satisfy present and future demands?". Thus the availability in space and time of resources is at issue (Bouma & Van der Ploeg, 1975).

Resources are only available for a certain purpose if they are not being used or have already been consumed for different purposes. In a multi-resource area, the manager will usually be confronted with a variety of options for resource use. Some of these options comply with the goals set for use of the area, others do not. In such a multiple use situation, the whole of demands will often exceed the resource availability. Management changes in favour of one demand type will affect resource use by others. Any consideration for future demands will affect the present ones.

The basic concepts of economic science, dealing with allocation of relatively scarce goods, apply to use of natural resources. The basic concepts of ecological science, dealing with interactions of organisms with their environment, apply to physical constraints on use of natural resources. The paradigms of economics and ecology differ but may be integrated at the systems level (Van der Ploeg, 1972, 1976; Van der Ploeg *et al.*, 1987). The combination of economic and ecological notions as regards resource use may help the manager to solve his problems as regards multiple use to some extent (see also Rapport, 1984; Zucchetto, 1984; Svedin, 1985).

Nature conservation and the use of natural resources

"The conservationist sees his role as the custodian of natural resources where these are interpreted in the broadest sense to mean the whole of the non-cultural world." (Warren & Goldsmith, 1974).
"... the mandate to utilize and to manage all the scarce natural bestowments in this Creation as a good steward." (Goudzwaard, 1970).
The subtle difference between "custodian" and "steward", does not diminish the shared intention of both quotations, i.e. stressing the responsibility of mankind for a continued existence and availability of natural resources (see also Warren & Goldsmith, 1983).
Such definitions point at the ideological character of nature conservation. Indeed there is an international conservation movement; organizations like IUCN and WWF and publications like the World Conservation Strategy are outstanding examples. Nature conservation is believed to be a "good" thing to do. Ratcliffe, the U.K. nature conservation expert, argues this by stating (1986) that "The most fundamental values in nature conservation are expressed in this range of purpose - scientific, economic, educational, recreational and aesthetic". Such arguments have been analysed by e.g. Bouma & Van der Ploeg (1975), who also added two arguments that are not necessarily included in Ratcliffe's statement:

* stability arguments, pointing at steady-state situations because natural systems are able to maintain themselves (see also Paterson, 1972);
* ethical (normative) arguments, referring to the idea that any organism in this world has its own right of living.

Nature conservation usually refers to resource ecosystems rather than to natural resources. Ensuring the integrity of the resource ecosystem should then enable a modest use of resources for the mentioned purposes. If, however, strict non-use were adopted as an objective of conservation policy, the "conserved" portion of the environment would merely be eliminated from the list of resources (Ciriacy-Wantrup, 1961).

Conservational use of areas often means the exclusion of other possible land uses, mainly the "extractive" use forms (mining, forestry, agriculture). Designation of nature *reserves* is an obvious example, where conservational use of natural resources is land use in the strict sense. In many cases, however, nature conservation is partially achieved by management agreements with e.g. farmers. In such cases conservation is a "minor" form of land use alongside agriculture, forestry etc. (Usher, 1986a). A deliberate method to achieve conservational use in a multiple use context is the creation of "National Parks". In some countries (e.g. France and the United Kingdom), National Parks may incorporate a variety of use forms next to conservational use: recreation, water-supply, non-intensive agriculture and forestry, military activities and residential building (see Duffey, 1983, for an extended review). In the Netherlands, National Parks are intended to be used for conservational and for modest, extensive recreational purposes, notably wildlife and landscape interest; other use forms are to be excluded as much as possible (Anon., 1975a).

Nature conservation and other "minor" land use forms

Overexploitation of natural resources by agricultural land use, fisheries and timber and fuel wood production are well-known to conflict with conservational use. The World Conservation Strategy is focused on these conflicts. Also the stress caused in ecosystems by major pollutants (SO_2, NO_x, other noxious substances) is acknowledged as conflicting with conservation objectives. These human activities are all large-scale and ubiquitous; so are their impacts on ecosystems.
Also ubiquitous but mainly restricted to the local or regional scale are many other human activities that utilize natural resources. Just like conservational use, these land use forms are "minor" in relation to the ones mentioned above, both in their extensiveness and in the extent of their environmental impacts. An example of these "minor" land use forms is *outdoor recreation*, here defined as the whole of non-working human activities at some distance of the own residence. Many activities occur in the open air (therefore "outdoor") but camping or staying in a weekend house are also included. Tourism is defined here as recreation which is directed towards specific objects which are favoured (for pleasure or interest) by a great number of people. Outdoor recreation is often associated with the more general sociological term "leisure activities", while tourism is usually associated with the economic sector "tourist industry". Throughout this book we shall mainly use the term (outdoor) recreation except in cases where tourism is explicitly at issue.
Other examples of minor land use forms include water extraction or purification areas, shorelines managed for defence against the sea and high-tension lines. In all cases, local impacts on the natural resources ecosystem may be considerable in terms of damage to soils and wildlife. Yet they are minor in comparison to agricultural or forestry land use.

> *Consider the coastal sand dune area again. A lot of youngsters sitting near the path, transistor radio full sound. Two passing birdwatchers do not see very much chance for their hobby there and cross the dune valley towards a more promising observation post. Another walker despises both groups as they destroy the vegetation by sitting and walking; moreover, he prefers to be alone. On this weekend day, the scientist does not see these people trampling his vegetation sampling plot (he'll find out afterwards).*

Four different uses, all four conflicting. Not only there is a conflict between recreational and conservational use, but also different recreational demands are in conflict. There is no problem here if there is enough space and variety for all activities. The dunes as a resource ecosystem may be capable to absorb stress without being disturbed definitely. Conservational use aims at maintaining this kind of equilibrium.
The basic conflict between conservational use and other minor use forms appears to be the apparent multi-objective character of conservation

within the boundary condition of very modest (multiple) use. Almost all other use forms are after one more or less specific objective. Outdoor recreation is an exception where, as shown above, different recreational activities can come in clear conflict. Conservational use usually denies optimization of any use form as it has to serve the other use forms as well, without setting the resource ecosystem at risk. In the Dutch situation, National Parks are a good example of averting risks to resource ecosystems by attempting to minimize other use forms except extensive recreation.

Some of the causes and the impacts of the conflicts between recreational and conservational use have been analyzed in scientific studies. High visitor pressure on an area is generally assumed to affect its conservation values considerably. Therefore many existing nature reserves are not open to the public or have restricted public access. Solutions to such problems are rarely given; the manager is thus often left with uncertainties about the extent and the seriousness of the problem without being able to do the "right" thing at the right time. He even fails to know what "right" might be. So the solutions often applied are favouring conservational use and are restrictive towards outdoor recreation (and other use forms), without a good idea of the effects (both for the visitors and other users and for the conservation value).

Scope of this book

The manager of a multiple-used area consisting of resource ecosystems might want to know:

* what to do in case of apparent conflicts between users? Will action or no action be accepted by users and by policy-makers?
* what kind of constraints are met when trying to adjust something?
* what are the consequences of those adjustments?

Usually two types of "parties" are involved in such situations: the *users* (a heterogeneous group of consumers with conflicting options about the area) and the *policy-makers* (also a heterogeneous group of people who are able to influence the events affecting the area). There are two main types of constraints: bio-physical constraints as a result of the properties of the area, and political constraints as a result of political decisions regarding the region where the area is located.
There is a vast amount of scientific information on the use of natural resources, as well as on methodology on the subject. Usually the manager has no simple access to these information sources and he needs an analyst to collect the relevant bits and pieces. Even then the information may be confusing or contradictory, and possibly even not quite understandable to the analyst. Moreover, information about aspects of *multiple* use is relatively scarce, particularly as regards the mechanisms underlying impacts of different use forms on each other and on the resource eco-

system. Such information lacking, the manager is often left with no other choice than to use constraints (in terms of budget, acceptation, undesirable impacts like erosion or loss of wildlife species, safety) to and from each use form to determine his room for decision-making. This approach is necessarily a rough one. There is also no synthesis of the information about mechanisms and the information about constraints available.

Figure 1.1 shows a conceptual model of relationships between events, knowledge, management and other actions in the case of multiple use of an area. Events (1) occur in the area as well as "elsewhere", concerning

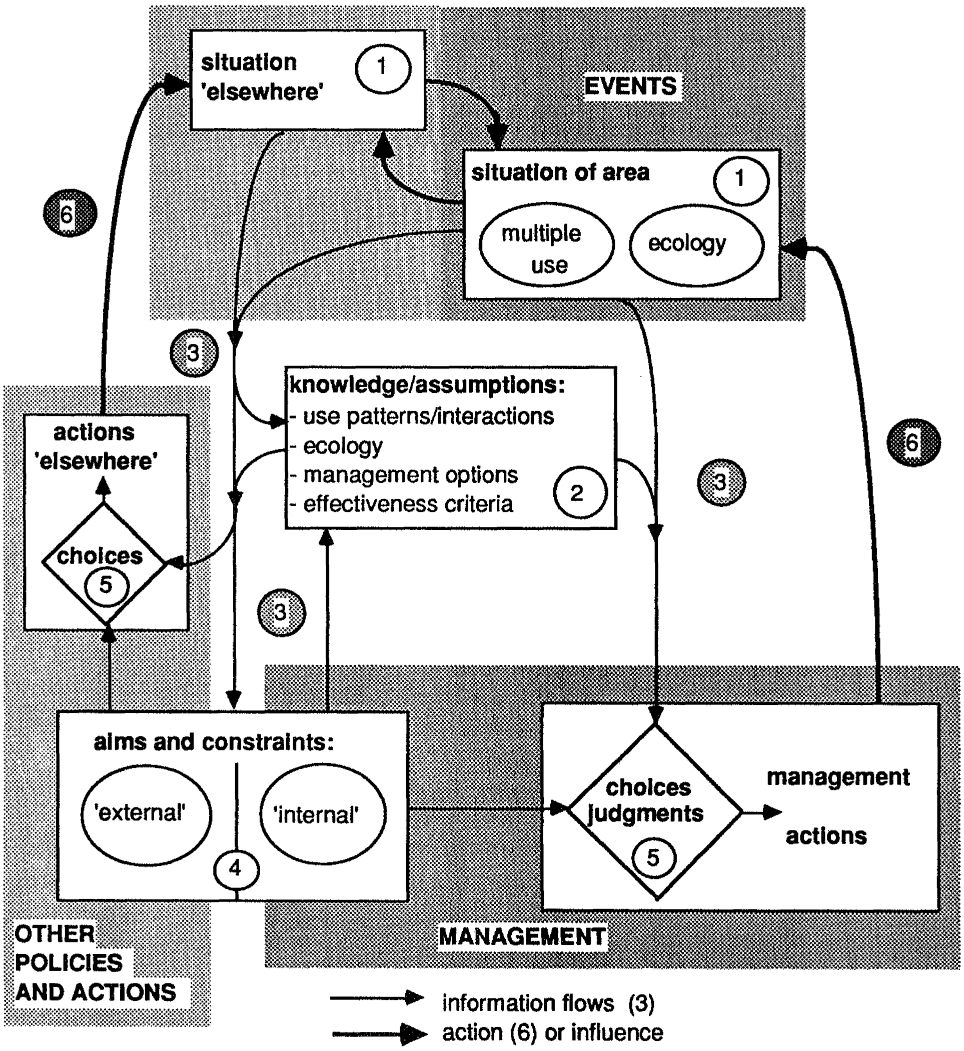


Figure 1.1. Conceptual model of interrelationships between events, knowledge, management and other actions.

both (multiple) use and ecological phenomena. Information (3) about these events feeds a "body of knowledge" (2) and also influences aims and constraints (4), choices and judgments (5), the latter being also fed by knowledge from (2) and by existing aims and constraints (4). Actions (6) as regards the area as well as the situation "elsewhere" result and these actions change the respective situations, causing different events to occur (1). It should be noted that the time scale for events, management and other actions may vary considerably, including time lags after specific actions have been taken.

This book aims to ***analyze and discuss management issues in multiple use areas*** in view of the problems stated above and with the aid of the conceptual management model shown in figure 1.1. It aims to bring forward information in such a way that alternative management options can be compared for their consequences in terms of effectiveness and efficiency. More precisely, following figure 1.1, parts of the "body of knowledge" (2) will be filled, links between events (1), knowledge (2), constraints (4) and choices (5) will be analyzed, and the consequences of actions (6) will be reviewed. Three restrictions, however, are made:

1) The book deliberately deals only with certain aspects of the whole problem of multiple use. In this book *outdoor recreation* is the core of the matter; it will be related to conservational use, water-supply and sea defence. Thus emphasis is laid on the "minor" land use forms.
2) Examples are mainly taken from our research carried out in two areas in the Netherlands: the "North Holland Dune Reserve" and the wetland area "Biesbosch". Both areas are nominated as National Parks, which implies a prime role for conservational use. Descriptions of the areas are given in Chapter 5.
3) No attempt is made to provide ready-to-use solutions for the issues that will be discussed. Usually there is no single solution but merely a range of options partially solving several problems.

The first part of the book (Chapters 2 to 4) contains a general analysis of three aspects of the multiple use of natural resources: understanding what multiple use is, resource ecosystem capacities and management of multiple use areas. This part provides a general basis for understanding the nature and the range of the problems involved.
The second part of the book reviews a series of real-world situations in respect of the management of multiple-used areas, with particular attention to the assessment of outdoor recreation impacts and to the management of outdoor recreation (Chapters 5 to 7). It also relates these results to the general analysis of the first part and it ends with some reflections (Chapter 8).

2. MULTIPLE USE OF NATURAL RESOURCES

This chapter deals with selected aspects of natural resource use and with multiple use of natural resources in particular. Firstly, multiple use of natural resource ecosystems is analyzed, with particular reference to interactions between different use forms. Secondly, several economic notions about natural resource use are reviewed in order to understand how resource use may be compared to use of other "production factors". Thirdly, patterns and processes in resource use are discussed, which may help us to get a better understanding of resource use interactions. Major attention is paid to recreational use patterns, and we mainly illustrate statements with examples from coastal dune use.
Finally, we stress the need for further analysis of use patterns and processes in relation to the qualities of the resource ecosystems used. Such analysis may help to formulate basic options and also constraints for resource ecosystem management.

Multiple use

Multiple use of natural resource ecosystems can be considered from three points of view:
1) the user's view (demand);
2) the resource system properties (supply);
3) the politician's and the manager's view (decision-making).
This chapter focuses on the first viewpoint and considers the other ones only in a general sense. Chapter 3 goes into details about resource properties; Chapter 4 deals with the political and management aspects.
For convenience we shall continue to use examples from coastal dune areas mainly. The analysis given here only applies to *areas* (mostly consisting of several resource ecosystems) which are in multiple use.

Characteristics of multiple use

Whenever a resource or a resource (eco)system is being used for different ends simultaneously, the overall use is called multiple use. This definition needs some specifications. Firstly, "different ends" regards the ends themselves and not the using subjects. Thus simultaneous use of a forest for timber production and outdoor recreation is multiple use,

while the use of that forest by different visitors (persons) to walk around is not. Secondly, simultaneity is considered on a period basis (one or more years) rather than different use occurring exactly at the same moment. However, at least one use form must cover the total period. The above example of forestry and outdoor recreation applies again while re-use of recycled minerals does not: purely consecutive use of resources is excluded from our narrow definition of multiple use.
An old-fashioned street-lamp may thus be multiply used (for illumination, for aesthetic pleasure and to tie a bicycle to). In analyzing multiple use we shall, however, focus on systems that contain natural resources rather than on specific objects. The example of the dune area in Chapter 1 shows a variety of use possibilities. Large areas usually give more opportunities for multiple use than small ones, if use forms can be spatially segregated. But even on a small surface use forms of a dune area like forestry, water-supply and outdoor recreation may go on together very well.
At this point a clear distinction should be made between actual use forms and possible (potential) use forms. Only on the national or international scale one could identify a "coastal dune region" or any other physical resource complex where all options can be realized simultaneously in a substantial way. Taking into account the boundaries of ownership or realms of management, most coastal dune areas are too small to encompass all options. The demand from the whole range of use forms may thus largely exceed the supply of resources. Generally, in such cases multiple use is then defined according to political decisions.
Most demands for use do only regard particular areas, e.g. in the case of specific materials or in the case of residential building. Interestingly, Dutch conservationists claim the total surface of the coastal dunes for conservational use as dunes represent a substantial part of "nature" in the Netherlands, because of the plant and animal species richness. An analogous claim is held by recreationists, as the total landscape of dune ecosystems is an important amenity value.

In our example of a coastal dune area, multiple use is a historical fact rather than a planned situation. However, the intensities of the different use forms have changed through time. A short and partial account:

* for ages it has been used for grazing, as arable land, to dry the fishers' nets and to hunt and collect fruits;
* in the late 19th century it became in use (by an elite) for aesthetic pleasure and wildlife interest;
* in the same period the waterworks company started to extract fresh water;
* also in the same period the interest in coastal resorts as "healthy holiday" sites increased;
* in the beginning of the 20th century trees were planted for timber production;

* at that time also buildings and road networks were created;
* sea defence was organized;
* in the thirties, parts of the dunes were dug for sand extraction and for various other reasons (unemployment relief works);
* during World War II a military infrastructure was created;
* after the war the area was designated as a wildlife reserve;
* in the fifties the waterworks company started to infiltrate water from the river Rhine into the dunes (because of fresh water depletion), using large basins and canals;
* in the sixties outdoor recreation in the area was more and more enhanced; also scientific research was encouraged and educational activities were started;
* in the seventies the remnants of ancient activities (grazing, cropping) were ended;
* in the eighties, restrictions were planned as regards outdoor recreation and hunting; plans were made for deep-well infiltration of water rather than surface infiltration;
* the area was proposed as a National Park.

This considerable (partly consecutive) change in the multiple use configuration in 150 years has had important consequences for the users. The local people of the coastal villages have lost "their" ground. Water-supply and sea defence have become dominant use forms. Production of anything except drinking-water has been reduced to almost nothing. Outdoor recreation is being restricted to certain areas. Only "conservational use" seems to keep up to a certain extent with water-supply and sea defence options.
From this example we may learn at least two things. Firstly, multiple use should be analyzed as a process rather than as a pattern. Secondly, multiple use cases may be restricted by predominant use forms (in our example: sea defence and water-supply). A third lesson might be that the users have experienced their total welfare package to change quite considerably over the last fifty years.

Use interactions

Whenever areas are in multiple use, the use forms or the users will interact. Four general types of interactions between use forms can be distinguished (economists often mention the first three types only; e.g. Ciriacy-Wantrup, 1961).

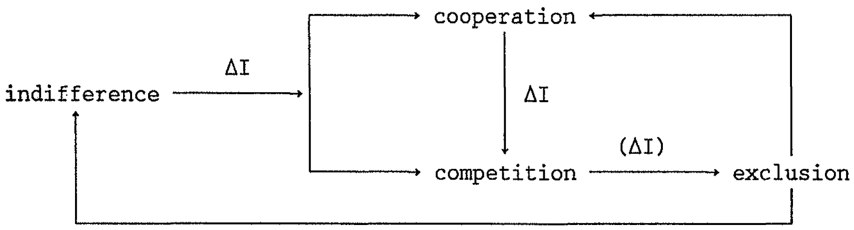
1. *Indifference*. This is the case if two use forms do not utilize the same properties of the resource or the resource system, or if they utilize the same properties only very modestly. In the above list of use forms in dune areas, forestry and hunting are examples of mutually indifferent use forms. Indifferent (also called "independent") situations are rather seldom if the area is relatively small and if the use options are relatively intense.

2. *Cooperation.* This is the case if two use forms can utilize the same properties of the resource (system) in the same way without consuming them in terms of extraction. Wildlife interest, aesthetics and refuge (i.e. conservation) may go very well together in "using" the same plants and animals. The same holds for sea defence and military objects.
   Cooperation thus depends on the characteristics of the use forms and does not depend on the extent of the area or on the intensity of the use options. It is often characterized by exclusion of other use forms (see below).

3. *Competition.* This is the case if two use forms claim to utilize the same properties of the resource (system) in such a way that one or both are forced to less use than in the case of absence of one of them. Intensive outdoor recreation may disturb wildlife or conservational use. Intensive water extraction interferes with forestry and grazing.
   Competition certainly depends on the area size and on the intensity of use forms. If competition can be avoided by using the area at different periods, there is a situation of indifference or even cooperation (in case of non-extractive use). Military training areas, for example, may be used by recreationists.

4. *Exclusion.* This is the case if two use forms cannot utilize the same property together at all. The most simple form is spatial exclusion: where there are buildings one cannot grow trees; sea defence is not helped by excavating sand from the defending dune system.

Relationships between these four types of interactions are indicated in the following scheme (ΔI denoting an increase in use intensity):



From an indifferent interaction because of low use intensities, increasing use intensities lead to cooperation or competition. But also cooperation can turn into competition if use intensities further increase. Competition often leads to exclusion (not necessarily by increasing use intensities) and this may lead to cooperation or indifference between the use forms that remain.
Partial exclusion is a general phenomenon related to indifference, cooperation and competition. In large areas partial spatial exclusion may be

considered indifferent interaction. Partial exclusion in terms of days or seasons is a form of competition. Depending on the intensity of use, exclusion may vary from partial to total.

Although these different types of interaction seem widely acknowledged, only about competition a good deal of information is available, mostly concerning competition between two use forms. One of the few exceptions is the compatibility matrix of land use forms by Green (1977), shown in figure 2.1.

exploitative	arable cultivation																									
exploitative	ley grazing	/																								
exploitative	unenclosed grazing	X	X																							
exploitative	softwood forestry	/	/	X																						
exploitative	hardwood forestry	/	/	/	/																					
exploitative	coppice production	X	X	.	X	/																				
exploitative	mineral extraction	X	X	/	.	.	.																			
exploitative	water supply	X	X	.	.	.	.	/																		
exploitative	drainage, canalisation, sea wall construction	.	.	.	.	.	.	X	X																	
exploitative	MOD training	/	/	.	.	.	.	.	.	.																
recreational	sailing	.	.	.	.	.	.	.	.	.	/															
recreational	water-skiing	.	.	.	.	.	.	.	.	.	.	X														
recreational	fishing	X	X	.	.	.	.	.	.	X	.	X	X													
recreational	shooting	X	/	.	.	.	.	.	.	X	.	/	X	.												
recreational	riding	X	/	.	.	.	.	.	.	.	/	.	.	.	.											
recreational	bird-watching	X	/	.	.	.	.	.	.	X	/	X	X	.	X	.										
recreational	rambling	X	/	.	.	.	.	.	.	.	X	.	.	.	.	.	.									
recreational	picnicking	X	/	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.								
protective	wildlife protection	X	/	.	.	.	.	.	.	X	.	X	X	/	/	/	/	/	/							
protective	maintenance ecological sites	X	X	.	X	/	.	X	/	X	.	/	/	.	.	/	.	/	/	.						
protective	maintenance archaeological sites	X	/	.	X	X	.	X	/	.	.	.	.	.	.	.	.	/	.	.	.					
protective	maintenance geological and physical features	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.				
protective	landscape protection	X	/	.	/	.	.	/	/	X	.	.	.	.	.	/	.	/	.	.	.	.	.			
protective	air quality	X	/	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
protective	water quality	X	/	.	.	.	.	/	.	/	.	/	/	.	.	.	.	.	.	.	.	.	.	.	.	
protective	rural life	/	/	.	.	.	.	.	X	/	/	.	X	.	.	.	.	X	/	.	.	.	.	/	.	.

Key

- . compatible or rarely competing
- / incompatible but conflict rare or restricted
- X conflicting

Figure 2.1. Compatibility matrix of competing land use activities in the countryside (Green, 1977).

Consequences of interacting uses

As regards the changes in multiple use of a dune area listed before, "indifference" and "cooperation" interactions have always occurred but have presently been overshadowed by competition and exclusion of use forms. As might be expected from a population increase in the Netherlands from 3 million people in 1850 to 15 million by now, pressure to use areas for general purposes rather than for private profit has gained momentum. Actually, almost all coastal dune areas in the Netherlands are nowadays owned by public authorities, and only few parts are still private property. As regards the overall use of the dunes, there has been a shift from "productive", extractive use forms towards other, partly non-extractive use forms.

The problems the manager is facing as regards interactions of different use forms are:

1) some actual use forms exclude other use possibilities;
2) some actual intensive use forms outcompete others;
3) some use forms must be excluded because of political reasons;
4) some use forms must be included for political reasons.

Indifferent and cooperating interactions are therefore much less important than competing and excluding interactions. Evidently again the total volume of the demand resulting from all use forms is much greater than the resource can supply. Thus choices have to be made as regards the desired levels of use for each of the use forms. Such choices about the utilization of scarce goods are the realm of the science of economics, and therefore we shall analyze some economic concepts in more detail, in order to get the demand problem in multiple use situations clear.

Economic aspects of natural resource use

Natural resource economics has a long tradition and many authoritative books have been published on the subject (e.g. Ciriacy-Wantrup, 1952; Krutilla & Fisher, 1975; Howe, 1979; O'Riordan & d'Arge, 1979; Fisher, 1981; Kneese & Sweeney, 1985; Collard *et al.*, 1988; Turner, 1988a). Rather than producing another review, we shall focus on three aspects in (resource) economics that are important for multiple use of natural resource ecosystems. The first one is the difference between private and public goods, in view of valuation of benefits from resource use. The second aspect concerns the "stock" or "flow" characteristics of the resource used, as this directly relates to the supporting resource ecosystem. The third aspect to analyze is the way resources are being consumed: "extractive" or "non-extractive". Other important aspects that are not analyzed here, are economic growth and resources, forms and effects of scarcity, optimal resource use over time and intertemporal comparisons of well-being (cf. Howe, 1979).

Resources as private or public goods

Let us return to the dune area as an example. If privately owned or rented from any authority, the area can be used for production of commodities that are marketable. In the Netherlands and most western countries, this means that those commodities have some monetary value. But they are also characterized by the fact that they can be produced and traded in marketable units. From the use possibilities of page 2, agricultural use, forestry and use for sand extraction are obvious examples. Parts of the area could also be used for building houses. In all cases the character of the commodities (or "goods") is called *private*. Private goods are technically separable into units which can be sold on the market. Individuals compete against each other in using the good, and potential users can be excluded. There is rivalry in use and private (exclusive) property rights exist (Siebert, 1987). The price of private

goods is assumed to reflect the marginal, relative importance of those goods in satisfying needs of human beings. This importance is revealed in the choice between goods.
Looking at most of the other possible uses of the dune area, the above does not hold. As regards sea defence, water-supply, outdoor recreation, research, education or conservational purposes, there is no market where one can sell separate units to a price. Often it is even difficult to tell what a "unit" would look like. Such services (also called "goods") nevertheless often show *aspects* of private goods. A car can only be bought by one buyer (there is a market, so this is a "private good") at a time. Likewise, services sometimes cannot be used because other users came first. The judge can only do one case at the time; the recreation area may be filled up with visitors.

Natural qualities like fresh air to breathe and pure water to drink were provided in such quantities in the past that they were considered "free goods": no money or effort was required to obtain them. Consequently, there was a zero price for such qualities. At present, for most of such qualities efforts are required to enable an undisturbed supply. If, for such services, no rivalry in use exists, and if no exclusive (individual) property rights for the service exist, we call the service a *public good* (Siebert, 1987). A lighthouse in our dune area may serve as a prototype of such a public good, as all ships may use its light without rivalry and without the chance of being excluded from use.
Some of the services from our dune area do not comply with the definitions of private and public goods given. In our example, exclusive property rights are not clearly defined, but there is certainly rivalry in use, e.g. the mentioned congestion. This type of goods is called a *common property resource*. Classical examples are the fish populations (as a protein source) in the world oceans and the "commons", pastures used by rural communities for grazing. The "Tragedy of the commons" (Hardin, 1968) exemplifies the problems that arise when rivalry in use exists without exclusive property rights: the resource becomes depleted.
Table 2.1 shows the above classification of goods according to the characteristics of use and the institutional arrangements.

Table 2.1. Classification of goods (after Siebert, 1987).

	Institutional arrangements:	Exclusive property rights		Non-exclusive property rights
Characteristics of use: Rivalry in use		Private good	I	Common property resource
Non-rivalry in use				Public good

I denotes intermediates between categories.

The above analysis applies for single-purpose use of commodities or services. In case of multiple use, the resource may be both a private and a public good and also a common property resource, as long as property rights exist but are not exercised. Once this is done the good becomes just a private good. Pheasants, for example, in dune areas certainly have amenity value. If they would be hunted, they would hide or be killed; the amenity value disappears. If hunting would be free, the pheasants would be a common property resource; in the case of hunting permits, the pheasants become a private good.
In the case of public lands (e.g. our dune area) we perceive a comparable situation; multiple use of a multi-resource area (see Krutilla & Fisher, 1975, for an extensive discussion). Again the goods supplied may have the characteristics of private goods (hunting leases), common property resources (berry picking) or public goods (amenity aspects). For public lands the manager (and, beyond him, the politicians) largely decides upon property rights and rivalry of use (e.g. in regulating congestion).

The resource ecosystem is not directly in consideration here. The system (or area) is no good or commodity in itself but it can be used to provide goods and services (see also Lambooy, 1975). A car is a resource but is almost worthless unless the owner has a driving license; the purpose is mainly driving, not owning the object. The same holds for systems providing natural resources: the resources are wanted by certain consumers but these consumers do not want the system itself. Even conservational use does not claim an ecosystem as an integrity to be utilized, although it mostly claims that that integrity enables utilization of aspects of it. Resource ecosystems thus are a production factor rather than a product.

In the example of the dune area, a host of (possible) users is claiming properties of the area for their own interests (for satisfying their demands). The manager is one of these if he has to produce something, for example drinking-water or timber. Using properties of the area for producing private goods implies a market for separable units. Using properties of the area as a common property resource or for producing public goods (services) like sea defence or recreation mostly cannot directly be valued in terms of market value (money), although hunting leases (part of "recreation") are marketable. In allowing use of the dune area for anything but the production of private goods the manager is thus confronted with the problem that this cannot be valuated in terms of money. Yet maintenance of the area requires part of his budget.
There are two ways of coping with this problem. One is to try to formulate "shadow prices" to any good (commodity or service) produced by the resource ecosystem (the dune area). The other is to look for valuation methods that include other value denominators than money.
In the first case, methods that estimate values (prices) of goods without an existing market include:

- *direct valuation* techniques (e.g. "contingent valuation"). These are based on the "willingness to pay", i.e. the amount of money that people would pay for goods that they currently receive free (Freeman, 1985);
- *market-based* methods like the travel cost method developed for assessing the benefits of outdoor recreation areas. Travel costs to such areas are assumed to reflect the preferences of recreationists (Clawson & Knetsch, 1966);
- *indirect valuation* techniques like "hedonic pricing", estimating implicit prices of the characteristics which differentiate closely related products in a product class (Freeman, 1985). A well-known example of such differentiating "characteristics" is air pollution in relation to house prices (James *et al.*, 1978);
- *the shadow project* approach (Klaassen & Botterweg, 1976), also called replacement cost method (Thibodeau & Ostro, 1981), calculating costs of re-establishing goods and services flows from a resource forgone by creating a comparable resource elsewhere.

In the second case, monetary methods may be mixed with non-monetary valuation methods. The latter include:

- *the energy theory* approach (Odum, 1983; Costanza, 1984; Turner *et al.*, 1988) where an artificial "market" is created, based on the energetic value of human operations. Application to ecological and economic systems would, under ideal circumstances, be equivalent to the willingness to pay approach;
- *ecological evaluation* (Van der Ploeg & Vlijm, 1978; Van der Ploeg, 1986a; Usher, 1986) as a method to rank areas according to their conservational interest.

Such evaluations may either explicitly or explicitly be allowed to override market values or shadow prices. "Goods" for which this holds are referred to as *merit goods* by economists (Opschoor, 1974; James *et al.*, 1978; Siebert, 1987).

This selection of methods shows that valuation of public goods and common property resources has certainly drawn attention from economists and other scientists. Yet such valuations have only limited importance, mainly as regards a legitimation of the management policy adopted in the past or preferred in the future. This is particularly the case for public lands that are in multiple use, e.g. for timber production, outdoor recreation and nature conservation (McConnell, 1985). Generally, these different methods also produce different results (in terms of prices) and there is no general agreement at all about which method would reflect economic reality best. Moreover, they are not really applicable to services like sea defence, military use or nature conservation in our example of a dune area. Such services are normally regarded as *merit goods* precisely because it is felt that their true significance to society as a whole is not reflected in market values.

Managing multiple use, particularly in the case of public lands, therefore requires decision-making based on revealed market prices, estimated non-market prices, non-monetary value judgements and socio-political preferences. There is no standard procedure to assemble these different value considerations into decision-making that is Pareto-efficient, i.e. it does not "increase the utility of affected parties at any point in time without decreasing utilities at other points in time" (Howe, 1979; p. 151). Nor is efficiency the only criterion that is taken into consideration by public decision-making. Usually governmental interventions take place in such cases, e.g. through corrections of market prices. However, even political interventions like levies, taxes, compensation or physical standards (e.g. for pollution) are only partial solutions for the problems studied here: they are usually directed towards one use form only. This even holds for "safe minimum standards" (Ciriacy-Wantrup, 1959; Turner, 1988a) for conservational use, as they may prohibit extension of other use forms by risk aversion rather than by assessment of use interactions that are obviously detrimental. We shall return to this subject in Chapter 4.

Natural resources as stocks or flows

Ciriacy-Wantrup (1952) has made a distinction as regards the character of goods used by society, into stock goods and flow goods. Stock goods are finite and therefore depletable, flow goods are infinite and non-depletable. Howe (1979) prefers to use the term "stocks" only, emphasizing the depletable or non-depletable characteristics. As all natural resources except some energy forms (sun, wind, waves) are ultimately depletable and in most cases not renewable, we prefer Ciriacy-Wantrup's classification.

Mineral ores and fossil fuels are well-known examples of stock goods. As regards our example of a dune area, the sand is partly a stock good; once extracted, there would be nothing left but there is suppletion from the sea. Extraction of ground water, exceeding the natural supply by rainfall, would also deplete this stock without additional supply by means of infiltration. All other use forms mentioned, however, relate to a flow character of goods provided by the area. Modest timber production would be possible without replanting; the same holds for agricultural use. Hunting pheasants or ducks may reduce the population but would not really deplete it, as long as such animals would survive in other areas and might recolonize the dune area.

Natural resources are supplied by ecosystems and these are productive in the sense that organisms produce offspring. Almost always their birth rate (natality) exceeds their death rate by senescence. If human consumption modestly uses this production, ecosystems deliver flows of goods, except when abiotic substances like nutrients go short, or when other impacts from human activities adversely influence the regenerative processes.

Many flow goods get a stock character if the rate of consumption exceeds the rate of production. This particularly holds for all goods produced by biotic activity. Even fossil fuels (not extracted in our dune area but in the adjacent one) are flow resources if considered on a time scale of hundreds of millions of years. If we set the time horizon to a maximum of one thousand years next, fossil fuels become obvious stock goods. The same holds for particular plant or animal species; once extinct, their reappearance as a result of evolutionary processes is improbable within the period chosen. According to Ciriacy-Wantrup (1959), economic reversibility may be lost even if such flows of resources do not reach zero but reach a "critical zone" where use becomes almost impossible, unless at very high costs. Admittedly such irreversibility depends on future technology, wants, preferences, substitution possibilities and social institutions (see also Bouma & Van der Ploeg, 1975). We shall return to this subject in Chapter 3.

In managing a natural resource area, it must thus be kept in mind that any use form may deplete the resource stock in a rate related to the intensity of use. Only when use of resource commodities balances production by the ecosystem, the resource keeps its flow character.

Extractive or non-extractive use of resources

Extractive use of resources has been defined in Chapter 1. Most use forms with the purpose of production of goods (food, timber) are extractive. Most "immaterial" use forms (aesthetic pleasure, other forms of conservational use) are non-extractive. Extractive use means finite use. The same tree cannot be cut twice. Non-extractive use is infinite as long as the resource exists. Extractive use finally creates some kind of waste, while non-extractive use does not.

Some use forms of natural resources are hybrids as regards extraction. Outdoor recreation is partly extractive (fishing, hunting), partly non-extractive (enjoying the scenery). Grazing in low intensities is extractive but does not deplete the resource dramatically. Often a use form is "extractive" as regards space: buildings or roads do not allow other use forms of a location, too many recreationists cause congestion and prevent others to use the same area. This spatial occupation is usually time-dependent. Buildings can be removed, congestion only occurs on peak tourist days.

There is an obvious relationship between stock/flow properties of resources and extraction. Extractive use is related to stocks, or to flows that are over-exploited. Non-extractive use is related to flow resources only, as are the hybrid use forms.

The manager of a natural resource area may consider that non-extractive use of the area may be profitable for a very long time. However, as said before, it is very difficult to fully assess the profits. Using the area for extraction, particularly for the production of stock goods, yields recognizable profits but the resource will be depleted. The choice how to use the area is, again, a political issue.

Finally, seemingly "non-extractive" use by recreationists, scientists or comparable visitors may cause stress to the ecosystem, for example disturbance of breeding birds or trampling of plants. Too much stress may lead to local extinction of some species; this situation may also be called extractive use, even if the ecosystem can recover from the stress by means of (partial) exclusion of visitors.

Summary

By now, we have introduced a set of problems the manager encounters in decision-making about the preferred use of his area:

1) the problem of monetary benefits of marketable goods versus non-monetary benefits of extra-market goods;
2) the possible depletion of stocks and of flows that take on stock characteristics;
3) the problem of the balance between extractive and non-extractive use;
4) the problem of dealing with spatial and temporal aspects;
5) the problem that many decisions are political (because of property rights and institutional arrangements) and therefore cannot be made by the manager only.

Table 2.2. Resource use aspects of a coastal dune area

	Supply of goods:			Resource type:		Use type:	
	private---	cpr---	public	stock-----	flow	extr----	non-extr
<u>Productive use</u>							
Arable land	•			•---------	•	•	
Grazing	•-----	•		•---------	•	•---------	•
Timber	•-----	•		•---------	•	•	
Sand extraction	•-----	•		•---------	•	•	
Water-supply	•-----	•-----	•	•---------	•	•	
<u>Carrier use</u>							
Buildings	•-----	•			•	•---------	•
Roads	•-----	•-----	•		•	•---------	•
Sea defence			•		•	•---------	•
Military objects			•		•	•---------	•
<u>Recreational use</u>							
Outdoor recreation	•-----	•-----	•		•		•
Wildlife interest	•-----	•-----	•		•		•
Collecting	•-----	•-----	•	•---------	•	•	
Hunting	•-----	•		•---------	•	•	
<u>Conservational use</u>							
Research		•-----	•		•	•---------	•
Education		•-----	•		•		•
Aesthetics			•		•		•
Refuge			•		•		•

cpr denotes common property rights.

As a partial summary of the problems involved in multiple use of an area, table 2.2 shows the various economic aspects in relation to some of the use forms of a dune area stated in this chapter. The use forms are classified in four main categories, partly following Van der Maarel & Dauvellier (1978). Actually they (and also Bouma & Van der Ploeg, 1975, and other Dutch authors) call these use forms "functions of the natural environment". We prefer to follow the Anglo-American custom to restrict the word "functions" to ecosystem processes that enable resource use (cf. Turner, 1988, 1988a).
Looking at the four main categories, there is a striking contrast between productive use (mainly private or common property, stock/flow, extractive) and conservational use (mainly public, flow, non-extractive). Carrier use is an ambiguous category; recreational use clearly can be distinguished into "exploitational" and "non-exploitational" use.

Almost any choice in a multiple use situation leads to a reduced utilization for one or more use forms. Many use forms of natural resources like coastal dunes are non-extractive and utilize the resource as a public good with a flow character. Therefore multiple use can certainly not be evaluated and optimized in terms of a market mechanism. Ciriacy-Wantrup (1961) concludes that the concept of multiple use should not be an economic interest *per se* but should be seen as part of legal and administrative institutions dealing with resource allocation, particularly as regards public lands. At most a partial evaluation of costs and benefits is possible. We shall return to this subject in Chapter 4.

Use patterns and processes in outdoor recreation

In managing multiple use areas there is often a wide choice for paying attention to various use patterns and processes. Focusing on the interaction between recreational and conservational interest, for example, most attention should go to recreational use which measurably influences parts of ecosystems that are being considered worth preserving. In other words: recreational use that bears no relationship to 'conservational interests' at all, is thought to be of low importance for this multiple use management issue.
The first problem encountered is then of course: how to assess such relationships? Apart from clear situations like impacts of trampling, phenomena like colours of coats or even sun reflection by lenses of field glasses might be important in the case of disturbance of birds (see e.g. Van der Zande, 1984). Thus it may usually be important to get a thorough picture of any recreational use pattern or process.
Pattern and process are separately mentioned here in order to stress the importance of both spatial and temporal phenomena. For convenience, however, hereafter we shall only use 'pattern' as a general term with a descriptive, analytical and statistical connotation.

Basic features in relation to multiple use

As regards possible interactions because of multiple use, recreational patterns may be surveyed with respect to:
* their impacts on other use forms;
* the impacts of other use forms upon them;
* their dependencies on specific aspects of the resource;
* possibilities for managing them.

These aspects are all strongly related to the total pattern of activities within and physical properties of an area or, more specifically, a site within an area. This "total pattern" is the result of the total demand for the supply of resources by that site. The demand, in its turn, is determined by the characteristics of each separate use form, including benefit-cost considerations, preferences, presence of alternatives, acquaintaince with the area (or site) etc.
Figure 2.2 shows a number of variables that contribute to the recreation pattern in a hypothetical area at time t and location i. This scheme is

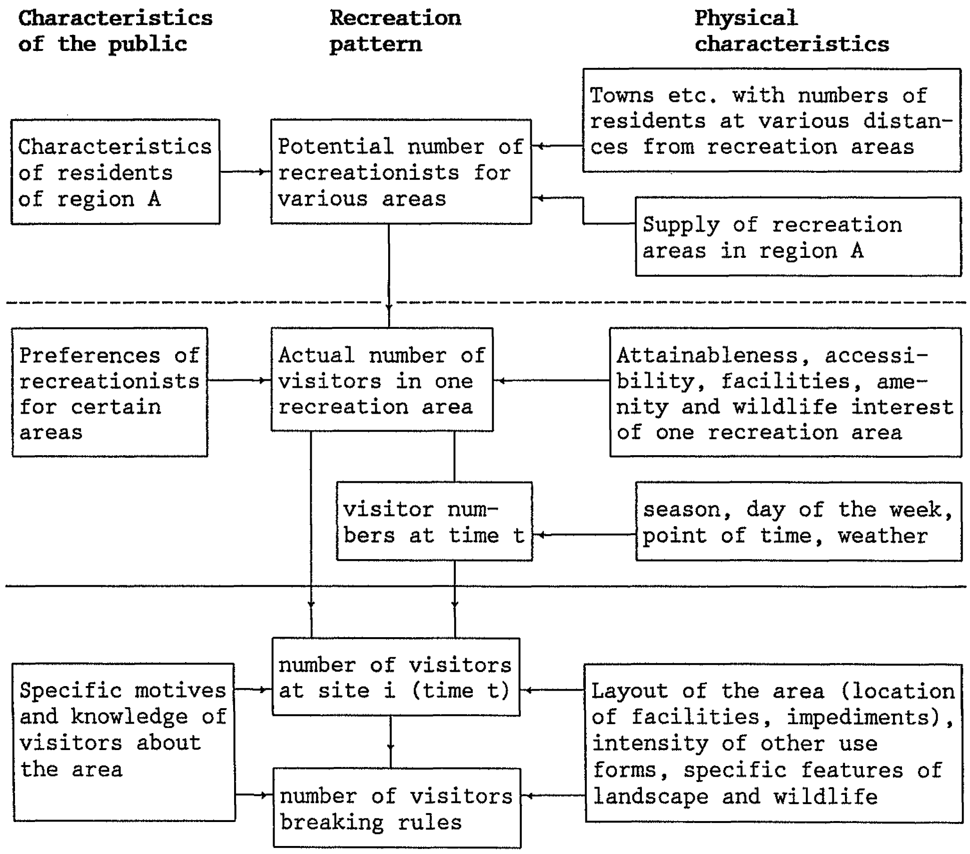


Figure 2.2. Characteristics generating recreational demands and recreational patterns (after Van der Linden & Van der Ploeg, 1982).

divided into two subschemes; the upper one for identifying the recreational demand for the area, the lower one for identifying the recreational pattern within the area, including influence from management and from other use forms. For convenience, the scheme does not distinguish between different recreational use forms.
The manager can change an existing multiple use configuration by influencing several variables like area and site accessibility (including entrance fees), the supply of facilities (and their location) and - partly - the amenity. Consequently, preferences for the area and specific motives to visit sites within the area will change, leading to a different recreational use pattern and to a different multiple use configuration. However, preferences and motives may also change through time because of changes in society as such.
The variables stated under 'Recreation pattern' result from the right- and left-hand side variables and from each other. However, these patterns are the results of *specific* combinations of visitors characteristics and physical characteristics for *different* recreational use forms. They are thus aggregates that cannot be traced back to simple explanatory variables. Such aggregated recreation pattern information is descriptive but not explanatory and its value for multiple use management can be questioned. Yet there is no good alternative, as frequent interviews with visitors at many different sites (in order to get knowledge about their profiles in terms of figure 2.2) seems virtually impossible because of costs and would also be a nuisance to the visitors.

Spatial and temporal aspects

Recreational use patterns of an area may be analyzed and also regulated at three spatial levels.
1) The regional level. As partly shown in figure 2.2, the demography (e.g. urbanization) and the supply of suitable areas in any region determine the final visitors demand. Of course a partial demand from other regions or even from other countries should not be neglected.
From the international literature on the subject the *distance* factor emerges as principal. Only in case of exceptionally strict preferences distances play a secondary role; in all other cases time costs and budget considerations heavily influence any choice.
Another important issue to deal with is *congestion.* A concise review is given by McConnell (1985). Congestion instantaneously influences the actual use of an area and may also influence future choices for areas to be visited. Thus the economic value of recreation may be affected (Cicchetti & Smith, 1976; Smith, 1980).
Distance and congestion are very important as regards daytripper participation. Residential visitors are influenced as regards their initial decision but, once arrived, should be regarded comparable to inhabitants of towns and villages neighbouring the area under consideration.

2) The local level. Just alike the regional level, the (expected) distribution of visitors within an area is determined to a large extent by spatial features. These include the location of facilities, the infrastructure and the structure of the landscape (geomorphology, vegetation). Distance from the gates and congestion, however, also influence the distribution. The action radius of the average pedestrian recreationist usually does not exceed five kilometres. Depending on the extent of the area and the number and the distribution of entrances, the resulting pattern may show considerable differences. Again, congestion may affect the economic value of the area as such (McConnell, 1980).
3) The site level. The particular composition of features in a specific part of the area influences the behaviour of users at a microscale. The same spatial features that have been mentioned at the local level are involved. The site level is paramount in assessing actual interactions between users and physical aspects of the resource.

Use patterns in time tend to vary between hours, days, seasons and years. Depending on the use form these temporal variations are random to a certain extent. Recreational use in general can often be characterized relatively easily, as Sunday afternoons, weekends in general and holiday seasons show peak intensities. More specific use forms may be strictly random; the presence of one specimen of a rare bird species may attract thousands of birdwatchers, just like a ship run ashore attracts many beach and dune visitors who would normally not be there.
Temporal patterns are important for two reasons. In case of congestion it is useful to know when this occurs as people may be diverted to other (parts of) areas or even be warned off. Next, the pattern may bear an important relationship to some organisms, especially shy ones.
Finally the time needed by visitors to get to the area plays a probably important but disputed role in the choice for and the valuation of a recreation area (Smith *et al.*, 1983; McConnell, 1985). To a certain extent this time spending can be regarded as costs made to experience recreation, but often the journey itself is part of the whole satisfaction from the trip (Cheshire & Stabler, 1976).

Measuring and understanding patterns

The above analysis indicates that measuring use patterns may not at all be simple. For knowledge about recreational use patterns, we have to collect data at least for spatial and for temporal distributions. Such an investigation, if done completely, may take several years of work for large numbers of observers. No wonder that such research is never done, as it is not proportional to the questions to be answered. Usually some sampling is done, based on foreknowledge about the use form, the characteristics of the area and general trends in use patterns as indicated above for spatial and temporal aspects. From such sampling only general indications regarding the use pattern can be deduced, and not a detailed knowledge (see also De Bruin *et al.*, 1988).

In the case of multiple use management, most attention is to be given to the local level (i.e. the area as a whole). Some information about patterns at the regional level is needed for assessing at what time how many people want to visit the area. At the site level, information may be needed in order to optimize microscale multiple use.

Use patterns may be measured with three possible aims in mind:

1) assessment of the *actual use* in a certain period. It may be important to know what actually is happening. As already stated, the question 'why?' is only to be answered by investigations upon explanatory variables.
   We might want to know, for all, such patterns if a variety of management options are considered. Knowledge of the patterns may help to make a decision.
2) Assessment of the *changes in actual use* after some of the social or physical characteristics of figure 2.2 have been (deliberately) changed.
3) Assessment of 'impact rates' in order to use these in stimulus-response-relationships between use forms and resources (see Chapter 3).

The main problem remains to *understand* the use pattern. Why is it as it is, and what factors cause it to vary or change? Partly the foreknowledge serves to answer these questions, partly the sampling may lead to explanations based on correlations. In any case, management needs reliable information in order to head for the ultimate aims. If we misunderstand use patterns, we may choose for adverse management options. However, time and budget are limiting our desired extension and perfection of useful understanding. So there is a wicked choice between adequate knowledge and effective but not expensive data collecting. Or, in terms of research: between adequate explanatory modeling of use patterns and more simple results that are still effective in the sense of management decisions (Van der Ploeg *et al.*, 1987).
If all this holds true, we cannot restrict research to simple distributional data. We need to know what moves people to act as they do. If we do not know, we might have a twisted picture of what is actually happening. Apart from this knowledge, it may also be necessary to extend pattern analysis into *behaviour* analysis. Unless we understand the patterns of behaviour in our area, we may never understand the relationships between the users and the area.

Patterns of other use forms

Many other use forms can be described and predicted in much more detail than recreational use. Referring to the productive and carrier use forms shown in table 2.2, almost all of these do not change considerably over time and as regards spatial distribution, after they have been esta-

blished. They are therefore very well predictable. A possible exception is grazing (whether used for production or for nature management), as behaviour and preferences of animals are not always known and may be highly random in space and time.
Market considerations, social preferences and technological advance undoubtedly influence the extent and intensity of these use forms. Changes, however, will usually be gradual, except in cases like the first oil crisis in 1973. Water-supply is generally predictable within known limits. Well-known unpredictable changes in use are exceptionally dry summers (when water extraction has to be drastically increased) and pollution incidents in the rivers that supply water for infiltration.

Conservational use is mainly based on existing ecosystem patterns and processes. These tend to change slowly if they are not disturbed too much. Such disturbance may be caused by weather (hurricanes), by plagues (notably insects) or by unexpected events caused by other use forms. Apart from these exceptions, trends in conservational use can reasonably be predicted.

All use forms may change relatively rapid in extent or intensity as a result of decisions by owners, managers or politicians. Recent examples in dune areas include termination of timber production and agricultural use, opening or closing areas for outdoor recreation and extension or reduction of road networks. Even if the impacts of such decisions on the use form itself are predictable, the impacts on other use forms are often not. As a consequence of the four types of interaction between use forms, such impacts may vary from detrimental to beneficial.

The need for further analysis

In conclusion, recreational use is less predictable than other use forms, at least at a year-to-year basis or in shorter periods. Therefore two different management issues are at hand:
1) the *long-term* issue where all use forms may change in due time; this requires a periodical evaluation of multiple use aims and their realization;
2) the *short-term* issue where only recreational use and possibly grazing are unpredictable; this requires a certain level of control in order to enable realization of multiple use aims within a certain time period.

An analogous division can be made as regards spatial distribution of activities belonging to various use forms. The overall spatial pattern needs a different approach from that for micropatterns.

We have seen now that the demand side in multiple use situations is complex because of the nature of the demand. Further complications are added by changes in preferences in space and time. The same holds for the supply side, the natural resource which is being utilized in several ways.

The existing literature on multiple use does not help us very much. Some publications just analyze the topic in a general way (like we did in this chapter), e.g. Ciriacy-Wantrup (1961), Simmons (1974), Van der Maarel & Dauvellier (1978) and Green (1985). Other publications mainly elaborate on one use form in a situation where only two use forms go together, e.g. Krutilla & Fisher (1975) on outdoor recreation, Wolter (1977) on forestry and Bowes & Krutilla (1985), also on forestry. Only few publications contain a more thorough analysis of actual multiple use, e.g. Hammack & Brown (1974) and York *et al.* (1977). Most of such studies are highly specific and the results are not easily applicable to different multiple use situations.

In order to know what decisions to take in any specific multiple use situation and which consequences those decisions may have, further analysis is thus necessary. Firstly, we need to know what the "crucial" issues are. In this chapter some (theoretical) concepts about the demand side have been described; the next chapter does the same for the nature of the resource. Secondly, we have to find methods and techniques for analysis, decision-making and evaluation. Thirdly, we have to focus on the actual situation by gathering information about use forms and the resource. Fourthly, we must link demand and supply in various ways, in order to get insight into consequences of decisions.

3. CARRYING CAPACITIES OF RESOURCES

This chapter aims to analyze and to evaluate various concepts about the consequences of multipe use of natural resources. The concept of resource capacities forms the main theme; the capacity concept will be illustrated as regards recreational use.
Stimulus-response relationships and recovery will be discussed with regard to operationalizing the capacity concept. Special attention will be paid to examples concerning the impact of recreational use on ecosystems and to the usefulness of these concepts in case of multiple use. A simple model for carrying capacity is presented. The chapter concludes with an evaluation of the capacity concept.
Again we shall look at these issues from the viewpoint of the manager, mainly focusing on "minor" land uses like outdoor recreation and conservational use.

The concept of carrying capacity

As indicated in the previous chapters, the demand for a resource may exceed the supply, particularly in case of multiple use of the resource. Stock (non-renewable) resources may thereby become depleted, flow (renewable) resources may shrink and thereby widen the gap between demand and supply; they even may become depleted (by extinction or eradication), just like stock resources. In all cases the demands are decreasingly satisfied. The essay of Malthus (1798) on population growth problems in relation to food production as a limiting factor is a well-known classic example of what nowadays is called "carrying capacity". In that essay, the capacity of the planet to sustain the human population was at issue. Malthus expected a geometric growth of the human population and only an arithmetric growth of the supply of food. These processes would lead to starvation for a large number of people. Verhulst (1838) was the first to formulate such population growth as a logistic (or sigmoid) curve that approaches to an upper limit in due time, depending on the rate of growth. Figure 3.1 shows the logistic curve for a hypothetical situation where use intensity of a resource increases over time.
Carrying capacity is an important part of the ecological theories about population dynamics. All textbooks on ecology (e.g. Krebs, 1972; Begon *et al.*, 1986) discuss the concept and its shortcomings. The core of the concept is that competition between individuals of the same species

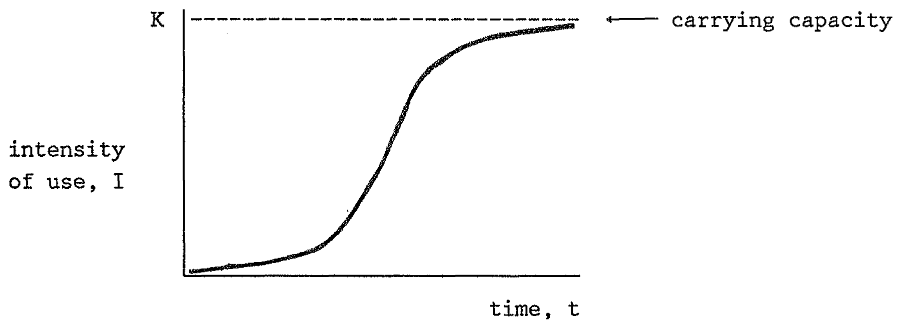


Figure 3.1. A logistic growth curve for increasing use of a resource.

or between individuals of different species can regulate populations at a density ("K") at which the birth rate equals the death rate. This density is called a carrying capacity because it represents the population size which the resources of the environment can just maintain without a tendency to either increase or decrease (Begon *et al.*, 1986, p. 209). Such an equilibrium is, however, only hypothetical; in natural populations, densities will oscillate around the capacity level, which, being a complex of dynamic variables, is also changing over time (see e.g. Vlijm, 1967). Carrying capacity thus refers to population sizes that are maximally sustainable over time. This is the reason that the concept has also drawn much attention from the side of range and game management (e.g. Wagner, 1969) and fisheries management (e.g. Clark, 1976). Because of the interweaving of these aspects of applied ecology with economic aspects they are often called bioeconomics (see Wilen, 1985, for an interesting state of the art). Carrying capacity is also considered important in determining the (maximum) sustainable yield from target populations.

In scientific literature on carrying capacities, three different levels of abstraction can be distinguished. These levels can be indicated in a spatial connotation:

1. Global capacity: the maximum total amount of human activities to be sustainable over time. Examples are found in the work of Boulding (1966; "spaceship Earth") and Daly (1973; "the steady-state society");
2. Regional capacity: the maximum amount of demands from the human population to be sustainable by the non-human environment over time in regions of countries or continents. Food problems in less developing countries tend to be paramount (see e.g. Opschoor, 1987; Pearce, 1988);
3. Local capacity: the maximum amount of demands from users sustainable by specific areas over time. Such areas may serve single-purpose aims (e.g. forestry, agriculture) or multipurpose (multiple use) aims.

This book explicitly deals with problems of *local capacities*. Hence we shall analyze these in detail in the next sections. Global and regional capacities will largely be neglected. Yet the overall issues are comparable, total demands possibly exceeding total supply over time in a multiple use situation, leading to competition between or exclusion of use forms, but they include both "major" (e.g. food and timber production) and "minor" land use forms (see Chapter 1). Global and regional capacity issues mostly refer to the survival of (part of) the human population. An example of defining capacity issues in relation to decision-making at the regional level is given by Ricci (1978). In his view, "...-carrying capacity requires the determination of critical factors and resources which are the principal determinants of social and economic life, and their interactions. These include the utilization and availability of renewable and non-renewable resources, population growth and the feedback mechanisms which relate these". For a capacity model, Ricci emphasizes that information should be gathered about the rate of changes of "incentives" (existing and perceived within the system, based on social, economic and other considerations) and about multiplier effects inherent to the system.

Multiple use and carrying capacity

The ecological concept of carrying capacity allows for both intraspecific and interspecific competition. In terms of multiple human use of natural resources supplied by a specific area, intraspecific competition would mean competition within one use form. An example is recreational congestion. Interspecific competition is analogous to competition between different use forms, e.g. recreation and nature conservation. We may even refer to the ecological "competitive exclusion principle", summarized by Hardin (1960) as: "complete competitors cannot coexist". Multiple use of exactly the same (properties of) resources would, in this analogy, lead to exclusion of all but the most successfully competing use form. Just as in ecological systems, such exclusion rarely occurs, but often a clear difference between dominant and non-dominant use forms can be observed. This implies that the assembly of resources generated by the area (the resource ecosystem) is not being completely in use by one specific use form but is also used partly by other use forms. Here two important differences between ecological carrying capacity and multiple use carrying capacity emerge.

1. In ecological systems, populations are assumed to grow until they reach the capacity level, i.e. until they maximally use the resources of the environment. In an *area* that is used for one or more human purposes, use intensities are not necessarily maximized but are dependent on a number of "exogenous" factors. Maximum use is only one of the possibilities.
   In ecological systems, populations exceeding the capacity level are "punished" because the resources partly deplete; thus the population

size to be sustainable decreases, which enables flow resources to recover, thereby re-increasing the capacity level. In an area in human (multiple) use, even flow resources may completely deplete, particularly when survival of the local human population is not at issue. Multiple use thus often lacks an important feedback mechanism.

In ecological systems, the resource supply that maintains the population is determined by the ratio of resource increase (by growth) to resource consumption. This only holds for human use in the sense of extraction of biotic flow resources. In multiple use situations, non-extractive use may increase even if extractive use forms are maximized. Reversely, maximization of non-extractive use does not at all mean exclusion of supply to extractive use forms. In this and the following Chapters, we shall use the term **stimulus-response (SR) relationship** for indicating the impact of consumption on the resource supply, and the term **recovery** for "growth" of the resource during or after use. More generally, stimulus-response relationships describe situations where the increase/consumption ratio is lower than unity, and recovery describes the reciprocal situation.

Changes over time

We have already indicated that carrying capacity may change over time as a result of consumption of the "carrying" resources beyond or below the capacity level. Resource availability may, however, also change because of several other reasons.

Firstly, the systems supplying resources are usually not constant. This is particularly the case in areas like dunes. Ecosystems change over time (ecological succession). Thus particular properties utilized by a use form may vanish spontaneously while increasing, or new properties (for example full-grown trees and invading plant or animal species) may enhance more use or even enable new use forms.

Secondly, the use form itself may not be constant. Recreational walking has been extended with "jogging" in the seventies. Sailing has been extended with "surfboard sailing". Both extensions cause a shift in the supply-demand relationship of the original use form.

Thirdly, the resource ecosystem may change as a result of overexploitation. If this change is *irreversible*, the resulting ecosystem will have different properties and thereby different capacities.

Finally, multiple use may cause interactions in the form of competition or exclusion. This may change both the properties of the area and the use forms.

If capacities are variable rather than constant, why trying to use this concept in decision-making? The simple answer is that, in absence of endogenous feedback control mechanisms, any effort to analyze and to quantify demand-supply relationships and their consequences is better than decision-making based on qualitative judgements or haphazard guesses. Actually the exact capacity level is not interesting; even a rough indication of the capacity can help the manager in deciding upon action.

Capacities for what?

As multiple use of an area may lead to the decline of use forms as a result of competition or exclusion, and in case this is undesirable, we are in search for capacity levels of use forms that do not obstruct the (minimally) desired intensities of other use forms. This necessarily means that, apart from the problem of variation in time, no single capacity level for multiple use can be assessed. Rather we have to assess capacity levels for each different use form. Starting with the use possibilities of table 2.2 (page 20), it seems necessary to determine capacities for all these use forms. However, there is little sense in determining capacities for use forms that are not actual. In our dune area example, cropping, grazing, sand extraction, military objects and hunting are not actual anymore. More precisely, the use forms which may interact are water-supply, sea defence, outdoor recreation, wildlife interest and conservational use forms. So we need to focus on such use forms as regards capacity issues.
Second, we have suggested to use a supply-demand ratio to indicate the capacity level. However, this is an *ecological* resource capacity, based on the ability of ecosystems to resist a certain intensity of stress or exploitation. If we are interested in a *technical* capacity, for example to build houses, we need to know the composition of the soil. If we want to maximize timber production or intensive tourism, we also need information about the necessary prerequisites for these use forms. In such cases the resource ecosystem is not regarded as an ecosystem anymore, but merely as a substrate for activities.
In the cases of outdoor recreation and of wildlife interest, *social* capacities may well be below the resource capacity. In other words, visitors may perceive congestion as a nuisance well before the resource gets into a clear depletion process.

All such capacities may be very different as regards their level and their claims on part of the supply by the resource ecosystems. Yet it is the ecosystem that dictates the intensity of any particular assembly of use forms as revealed in a total (cumulative) use pattern to be sustained over time. Different assemblies of use forms lead to different overall use configurations with accordingly different intensity levels that can be sustained. The manager has to decide upon the assembly of use forms and he would be helped very much in this decision if he would know the sustainability of any resulting overall use configuration.

Recreational capacity as an example

From the sixties (Wagar, 1964) until the eighties (Mercer, 1979; Beckers *et al.*, 1980; Goldsmith, 1983) the concept of recreational (carrying) capacity has been intensively discussed. This discussion is a good example of the problems encountered in trying to define capacities and to operationalize them in terms of decision-making. Outdoor recreation, as we already know, is a "multiple use form" in itself, as it comprises holiday-making, day-tripping, sports and specific wildlife interest. Thus an overall capacity definition would not seem easy at first sight. We shall briefly discuss some of the major issues that are also relevant for multiple use in general.

1. Capacity has been defined for **both demand and supply** aspects (e.g. CRRAG, 1970). Such definitions are of little use as the **lowest** capacity level usually determines the threshold for the manager to take action. This also holds for the explicit differentiation of biotic and abiotic aspects of the resource system; usually biotic aspects are more vulnerable for human impacts and therefore they primarily determine the capacity (e.g. Chubb & Ashton, 1969).
2. Capacity has been defined as **a single figure** for the whole of recreational activities (e.g. Chubb & Ashton, 1969; Burden & Randerson, 1972), in relation to resource aspects. Theoretically there may be such a single figure, but it is hardly conceivable that this will ever be assessed. Even in the case of a single recreational use form (e.g. walking), psychological and aesthetic perceptions of congestion individually differ (Wagar, 1974; Bury, 1976).
3. Capacity has been often defined as a possible **near-equilibrium** situation (e.g. Wagar, 1964; Speight, 1973; Brotherton, 1973). Apart from the mentioned changes in the resource supply as a result of use and of endogenous developments, a near-equilibrium may again be theoretically conceivable but hard to assess empirically.
4. Capacity definitions mostly include **aims and goals or value judgements** (e.g. LaPage, 1963; Wagar, 1964; Burden & Randerson, 1972; Van der Ploeg, 1973). Most of these refer to satisfaction of recreationists and the possible deterioration of the resource; some also include economic considerations (CRRAG, 1970) or the capacity of facilities (Heberlein, 1977). Many authors (e.g. Barkham, 1973; Goldsmith, 1974; Wagar, 1974; Bury, 1976), however, dispute that capacities, once aims and values having been defined, could be **objective figures**. Goldsmith (1974), for example, argues that ecologists do certainly not agree about ecological "values"; therefore any position chosen in defining an acceptable state of the resource is inherently subjective. The same holds for the determination of "satisfaction".
5. Many capacity definitions do not refer to the **role of management** (e.g. Chubb & Ashton, 1969; Brotherton, 1973; Anon., 1978). Should the manager use a capacity figure to take his decisions or should he decide upon desired qualities and quantities of use and hence have a capacity figure as an outcome? As capacities can not be assessed objectively, choices have to be made. The manager is responsible for choices, the scientist is not. Thus Udo de Haes & Van der Zande (1977) state

that the carrying capacity results from a political decision. Such a decision influences both the actual use level and the state of the resource (see also Van der Ploeg, 1973a; Goldsmith, 1974).

6. Only few definitions of capacity explicitly account for **processes**, i.e. capacities over time (cf. Beckers *et al.*, 1980). Most definitions implicitly assume a near-equilibrium which does not do justice to the dynamics of the resource. Many definitions refer to an "acceptable state" or to "deterioration" or to "permanent change" of the resource (ecosystem), but no definition includes a **starting-point** in time for such value judgments. Do we prefer the environmental quality of the 19th century, or the quality in about 1945? Without such a reference point, choices cannot be made explicit.
7. Finally, most definitions do not mention **spatial characteristics**; at most, use per surface area is mentioned (e.g. Tivy, 1972). However, it is self-evident that in a large recreation area the possibilities for visitor distribution, access management and resource management will strongly differ from those for a small area. Hence the carrying capacity may be completely different.

These considerations have led some authors to reject the capacity concept as a tool in decision-making for areas used by outdoor recreationists (Goldsmith, 1974, 1983; Wagar, 1974; Bury, 1976; Mercer, 1979). Yet all managers of such areas know that there *is* something like a carrying capacity; they perceive dissatisfaction and deterioration of the resource systems in cases where visitor pressure increases. If simple (or even composite) overall capacity figures cannot be assessed, it may be better to rely on specific information on the behaviour of the resource under stress from specific use forms. Hammitt & Cole (1987) state that the key to management of recreation in wildlands is specifying management objectives and monitoring conditions. They argue that while capacities *can* be set, these must either be wasteful of legitimate recreational opportunities or they must be only a small part of a management program.

In conclusion, the recreational capacity issue has certainly lost its glamour of the late sixties. However, the debate has undoubtedly increased the understanding of the various factors that are important in the intricate relation between visitor use and resource qualities. The message seems to be to measure these factors and to relate these measurements within the framework of management objectives (see also Van der Ploeg, 1987). Carrying capacities in relation to these factors and objectives may then still be a useful tool if applied in a flexible way.

Measuring capacities

Even if capacities may not be expressed as single figures for an area or a site, decision-making can be supported by collecting information about the relationship between any use form and the resource used. Such information can be used to approximate capacity levels, or, in the terms used by Hammitt & Cole (1987) to approximate "limits of acceptable change". Figure 3.2, as an example, shows a model of acceptable ecological change in wildlands. Such a "limit" is comparable to the "ultimate environmental threshold" as proposed for use of National Parks by Kozlowski (1983).

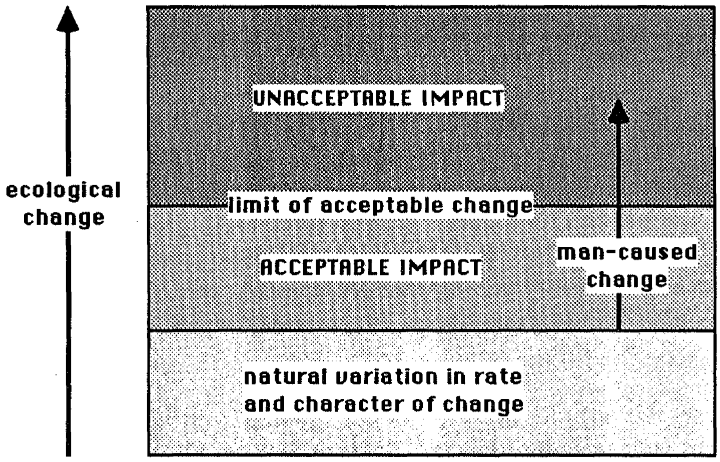


Figure 3.2. Model of acceptable ecological change in wildlands (after Hammitt & Cole, 1987).

As already stated, capacity can be formulated in terms of a growth/consumption ratio for a biotic resource. Basic elements for such a ratio are the following:

* stimulus-response relationships that indicate the impact of consumption on the resource;
* recovery rates that indicate growth of the resource under various circumstances, with special attention for irreversibility (i.e. a zero recovery rate);
* indicators for the resource or the resource ecosystem;
* use patterns of the resource.

Use patterns have already been discussed in Chapter 2. The next paragraphs are devoted to a conceptual analysis of the other elements. This chapter concludes with an attempt to integrate the elements into a simple conceptual model and with an evaluation of the capacity concept.

Stimulus-response relationships

Any resource being used responds to that use. Grassland that is being grazed or trampled is different from unused grassland. Groundwater extraction for water-supply may let the vegetation of an area suffer from drought. Noise and intensive activity may cause failure of breeding of animal species.

On the other hand, natural resource ecosystems are dynamic. They change over time, and seem somehow resistant to impacts from outside the system. People have used this property of natural resource ecosystems for ages to satisfy their demands for food, shelter and many other things.
Maximum *sustainable use* can be defined as the situation where human use and ecosystems dynamics counteract each other in such a way that the *status quo of* the resource remains roughly the same. This definition resembles the definition of carrying capacity given earlier, where the *processes* of growth and consumption were mentioned.
It is important to stress here that an implicit choice has to be made as regards two opposite use possibilities:
1) to use the resource, keeping it in the *status quo*;
2) to "use" the resource in order to let it develop in a natural way.
The second option, deliberately set within quotation marks, may be called "use by (almost) non-use". The development of an ecosystem as such, regardless what comes out, may be an educational (i.e. conservational use) option. In multiple use situations, however, the *status quo* option is far more relevant, be it that by particular management the multiple use configuration of the resource could also change.
Use can be divided into different actions. All these actions are stimuli to parts of ecosystems. Walking as a *motion*, for example, may not only lead to soil erosion and death of plants, but also startles animals. Components of ecosystems all show their own specific response to a certain stimulus, depending on their characteristics. And also responses to a certain stimulus may be different for each soil type, each plant species, each animal species.
If we want to know what sustainable use (and thereby carrying capacity) means for an ecosystem, we face the fact that the system as such cannot be measured (were it only because it is a model of the reality). Thus we have to select system variables (e.g. soil properties, certain organisms) that we think are important as indicators for sustainability. Each indicator will specifically react to a certain stimulus. By assessing these stimulus-response **(SR)** relationships we expect to find answers to questions about sustainability of use and about capacities.

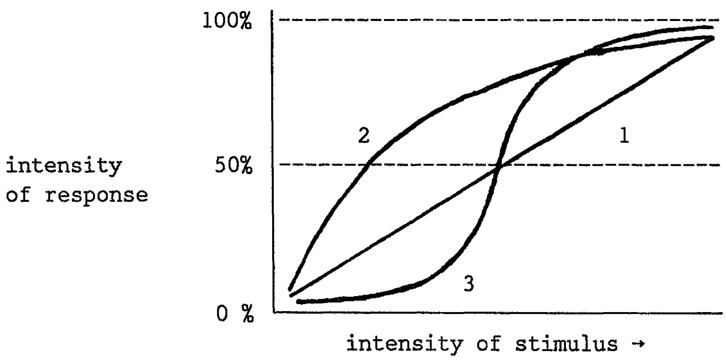


Figure 3.3. Basic patterns of stimulus-response relationships.

Basic features

Figure 3.3 shows three different conceptual possibilities of reactions of resource aspects to impacts. These curves are deterministic and heuristic (i.e. based on inductive reasoning from circumstantial evidence to get to an explanation). The curves have the following meaning.

(1) the straight line indicates a fixed relationship between the intensity of the stimulus and the intensity of the response.

(2) the hyperbolic curve indicates that the responding resource is already sensitive at low levels of stimulus intensity; a high response level is reached rather fast.

(3) the logistic (sigmoid) curve indicates that the responding resource is not very sensitive initially; as the stimulus intensity increases, it rapidly becomes very sensitive.

Most SR relationships show patterns like (2) or (3) in figure 3.3. Yet we may specify such relationships even in some more detail. As some organisms are very sensitive, others may expand where those sensitive ones have disappeared. Thus some organisms take profits from impacts like trampling or desiccation at low stimuli intensities; yet they also become affected if the intensity increases. Figure 3.4 shows a translation of this into a mathematical formula and its graphical representation (comparable to an inverse sigmoid curve).

$$P = \frac{P_0 + \beta * x^m}{1 + \alpha * x^n}$$

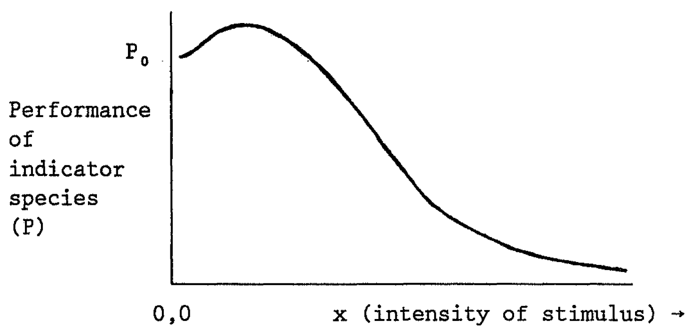


Figure 3.4. SR relationship for non-sensitive organisms.

The mathematical formulation can be explained as follows. P_0 denotes the original performance level of the indicator. At increasing intensities, the positive stimulation is represented by $\beta * x^m$, the negative stimulation by $\alpha * x^n$. Whenever $n>m>0$, P is bound to approach to zero.

An interesting feature of this formulation is that α and n, and β and m, respectively, counteract. A very small α means that negative response is only shown at high stimulus intensities. Therefore α indicates the *resistance* of the indicator, while n indicates the *sensitivity* of the indicator. Reversely, m indicates the growth rate of the indicator, while β stands for "containing" factors like availability of food and space. A very small β thus indicates full competition between the indicator and other organisms.

Multiple stimulus-response relationships

In almost any real-world situation we cannot isolate simple SR relationships. This can only be achieved (and even then only partially) under laboratory conditions. Usually a mix of stimuli leads to the response that is measured. This mix consists of two important components:
1) the whole of human activities influencing the receiving organism;
2) the whole of ecological circumstances (abiotic and biotic) influencing the organism.

Both components are "wholes" and are therefore mixes as well. If there is one dominant stimulus, a relatively simple SR relationship can be assessed. However, we are usually confronted with several dominant ecological stimuli and another set of dominant human stimuli. There is no simple way out of this problem. Multiple correlation or regression analysis, where different factors are analysed for their respective impacts on a receptor, at least indicate such dominant stimuli, thereby enabling a reduction of the number of explanatory variables. However, such a regression would have no general explanatory value as a different data set would produce different "impact pictures" for each of the stimuli. Therefore such methods are notably useful in *monitoring*.
On the other hand we must realize that we are trying to analyse a *management* problem rather than a scientific problem. Even if the ecological circumstances would largely determine the behaviour of the resource under consideration, the question still remains which manageable human use forms are exerting a relatively large impact. If a use form, or a human activity in the neighbourhood, cannot be managed, it is of little use to ponder over its importance.

We still hold that the manager's aim is to create or maintain a situation of sustainable multiple use of a natural resource. In order to achieve this, we have to assess the resource parameters that are critical, i.e. that indicate a change of the system. We have to monitor these parameters and we have to assess if they are strongly influenced by one of the use forms (or part of it). Next, we have to find a SR relationship between the use form and the resource. If so, we can act accordingly. If we cannot find such a relationship, we have to detect, at least in qualitative terms, what could cause that parameter to change.

Stimuli over time

The above relationships between stimulus and response are "transversal", i.e. they relate to spatially separated situations with different stimulus intensities from which a relation curve can be constructed. Most

impact situations, however, are "longitudinal", i.e. the stimulus (constant or varying) is exerted on the same receptor during a *period*. If the stimulus is constant over time the response will take the forms as shown in figures 3.3 or 3.4. If the stimulus is not constant, we are in problems again. Over a short period the stimulus may be random. The only thing to be measured then adequately is the ultimate impact at the end of the period. We may relate the average (measured) stimulus or the peak stimuli to the impact measured although we do not know if this relation is realistic. By means of repeated observations, however, we may improve our understanding of that relationship.
The real-world situation is even more complicated. Stimuli vary throughout a period (e.g. one year) but may be prolonged for a long time. Moreover, stimuli from different use forms may show a completely different periodicity, if we are able to discover any pattern in time at all.
If we consider the *receptor* to show a constant behaviour, this problem can be reduced again to the relationships introduced above. The receptor is then assumed to stay at a certain performance level during a period of non-stimulation. In most cases, however, this is not a realistic assumption, because the receptor will change either by its own dynamics or by other external influences. An example of the second possibility are semi-eroded sandy soils, notably on slopes. Once they have been worn by trampling, they are susceptible to abiotic influences like rain or wind. Semi-eroded soils are thus likely to erode completely as a secondary response to the whole of external influences.

Some examples

This paragraph illustrates the basic features of SR relationships, using data about recreational impacts on ecosystems, mainly sand dunes. We shall mainly draw on *experimental* field research, being the basis for understanding real-world situations. Further examples of SR relationships about real-world multiple use will be given in the Chapters 6 and 7.
The majority of these examples comes from original experimental research in the North Holland Dune Reserve (NHDR), done in 1973-1977. Several interim reports on this research have already been published (mostly in Dutch language), Littel (1974), Boomsma & Van der Ploeg (1976), Van der Ploeg *et al.* (1978), Ten Cate (1979) and Van der Linden & Van der Ploeg (1982) being the more important ones*.

Before presenting these examples, a general problem has to be stated. In experiments, influenced stands or samples can be compared with non-influenced control stands. In real-world situations the latter do not exist

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* Most of this research has been carried out with the intensive help of students of the Free University. In particular I owe very much to Ad Littel, Koos Boomsma, Leon Braat and Hans ten Cate.

(at least not in the vicinity of the influenced stands). That leaves us with the dilemma to choose between two inferior yardsticks:

1) to express stands as a percentage of a "control" that is also an influenced stand or is situated so far away that its control function can be questioned;
2) to express stands in real figures (heights, surfaces, volumes, numbers) whose bearing to real figures in remote experimental stands is equally questionable.

A compromise solution is then to compare control stands first ("real world" versus "experimental"), bearing in mind that local natural conditions may explain differences.

The stimulus: trampling.

Although there is ample information about the physical and mechanical aspects exerted by walking feet, much less is known about the actual influences. Experimentally performed stimuli (whether in the laboratory or in the field) are an approximation of this pattern.

Trampling will probably show differences between treading flat areas and slopes, respectively. Foot pressure on flat areas is dominated by its vertical force component while on slopes an oblique force will prevail.

In the scientific literature on recreation ecology, stimuli by trampling are often expressed in terms of "passages" (of people, of cars, of horses etc.; e.g. Speight, 1973; Liddle, 1975; Boorman & Fuller, 1977; Hammitt & Cole, 1987). In some cases, an experimental stimulus is expressed in "steps" (Blom, 1979). Passages may be converted into steps (Van der Ploeg *et al.*, 1978): every 4 passages can be considered to result into one step per surface unit. We shall use "passages" as these are more obviously related to recreational use.

However, actual recreational use can hardly be described in terms of passages. Only in case of regular path use, the stimuli in experimental and real-world situations are comparable. In most other cases, however, stimuli are exerted in a "random stratified" way. Illegal paths are created by passages and may be "maintained" by continuing use. Next, we may suppose that sites with a low vegetation cover (grasses, mosses, herbs) are more intensively used than sites with a tall vegetation (notably shrubs and small trees).

We conclude that only in the case of (legal or illegal) paths information about stimuli from experiments can be used. In all other trampling situations, the stimulus can hardly be estimated.

The response: damage to and changes in soil, vegetation and fauna.

Most plants (of various species) are not killed by trampling but rather damaged (stems, leaves), except for very high trampling intensities. Such damage is most obvious when looking at plant **height** as a parameter. As a direct result of this, plants may regenerate partly horizontally.

As a combined result of changes in soil structure (e.g. compaction) and changes in microclimate (the vegetation becoming more "open" by the

change in height), plant growth will be different in due time. For some species the environment becomes unfavourable and they will be outcompeted by other species that are more tolerant. Thus the vegetation structure and composition (and sometimes also the species composition) will change. Grazing patterns by animals (e.g. rabbits) also change as a result of the more "open" vegetation type and this again influences the vegetation structure.
Animals living in the soil, in the litter layer or in the vegetation may be killed by trampling. The changes in habitat (soil, vegetation structure) also affect these animal populations.

Stimulus-response relationships: some indicators.
Experimental research on impacts of trampling on dune ecosystems (Liddle, 1973; Littel, 1974; Boorman & Fuller, 1977; Van der Ploeg *et al.*, 1978; Blom, 1979) has shown that different soil, vegetation and faunistic parameters respond very differently to stimuli. This insight may be important from a scientific point of view but it does not help very much in situations where "overall" judgements (about soil, vegetation and animals as a unity) are required. From that point of view, selecting a range of indicators is useful. In most cases about recreational impacts we are interested in a continued performance of the ecosystem as the resource system for recreational use.
Intuitively, most likely parameters would then be:

1) important soil properties;
2) presence/absence of vegetation cover (including dead material);
3) vegetation volume (a combination of height and cover);
4) plant and animal species composition;
5) parameters of dominant or abundant plant and animal species.

Additional criteria for selection of parameters could be:

a) statistical possibilities for descriptions and tests;
b) relative unambiguity and absence of difficulties in recording the parameter.

Soil penetration resistance relates to the number of passages linearly (Liddle & Greig-Smith, 1975) if the logarithm of both variables is used. This variable is relatively easy to measure, in contrast with pore volume (laboratory treatment needed), although that variable is probably more explanatory as regards impacts on plants (Blom, 1979).
Bare ground is only substantially recorded in flat areas if the trampling pressure is extremely high or is high and is continued over a very long period. In the NHDR research we recorded bare ground cover percentages of 10% - 45% only in intensively trampled plots. This parameter is, however, useful on slopes where the soil is made loose rather than compacted. The same holds for horse trails; we shall return to these in Chapter 6.
Examples of SR relationships for penetration resistance and bare ground surface are shown in figure 3.5. Data for low (grasses, herbs, mosses)

vegetations have been derived from Liddle (1973; fig. 3.5.A) and from Boorman & Fuller (1977; fig. 3.5.B).

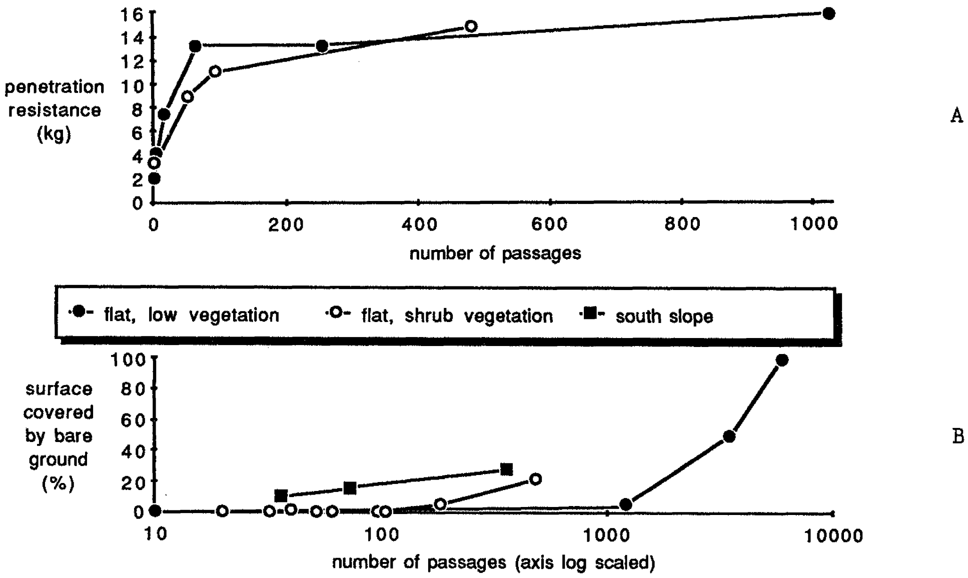


Figure 3.5. SR relationships between passages on paths and (A) soil penetration resistance and (B) surface bare ground.

Soil penetration resistance appears to be the more sensitive parameter (cf. the hyperbolic curve in fig. 3.3). Surface bare ground, however, is far easier to monitor. Differences between Boorman & Fuller's and our data in fig. 3.5.B are probably due to the difference in experimental trampling regimes: once a month during one year *versus* once a week during three months. Under the latter stimulus the vegetation has almost no chance to recover. Weaver and Dale (1978) report higher percentages bare ground in a comparable trampling experiment but their research was carried out in a meadow and a forest above 2000 m altitude.

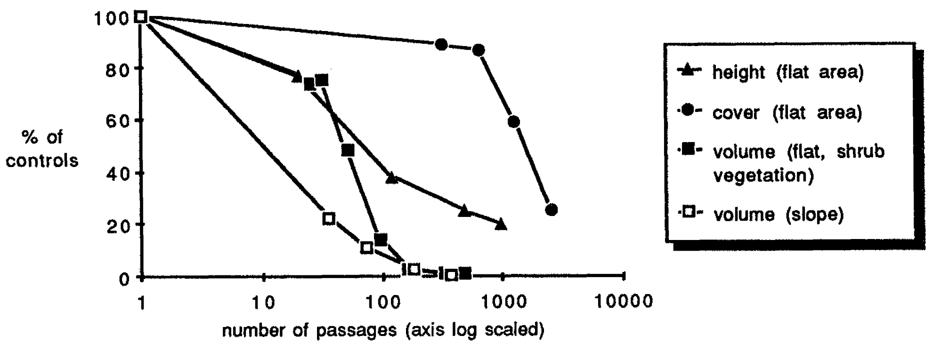
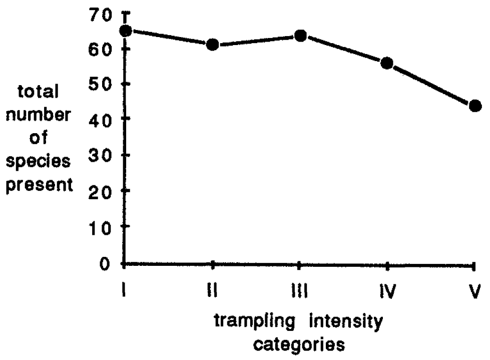


Figure 3.6. SR relationships between the number of passages and height, cover and volume of vegetations. Data are expressed as relative to control stands (=100%).

Total **volume** of the vegetation cannot easily be measured and is statistically less valid because of dependencies on different dominant plant species. Measuring the components of volume, height and cover, separately is easier but does not produce an overall picture. Figure 3.6 shows examples of these three parameters.
Data for **height** have been derived from Boorman & Fuller (1977), data for cover from Liddle (1973). **Cover** is apparently affected only with relatively intense trampling (cf. the examples for bare ground in fig. 3.5), height is more sensitive. Cover was, however, strongly affected in the experiment of Hylgaard (Hylgaard & Liddle, 1981), due to the dominance of one apparently vulnerable species, *Empetrum nigrum**. Slope vegetations are more sensitive than vegetations in flat stands. The data of Boorman & Fuller on heights correspond with those of Van der Werf (1970) for the Meijendel dune area in the Netherlands.

As regards **numbers of species** present, figure 3.7 shows results from Van der Werf (1967) in Meijendel (A) and from our research in the NHDR (B). Van der Werf's results refer to the occurrence of species in one of the categories in the research area as a whole. The scale of trampling intensity in fig. 3.7.A is based on a subjective division of transects (chosen at a right angle to paths) into five classes ranging from "undisturbed" vegetation to the centre of paths. Although this scale is not quantitative, it can be used as an approximation of the range between very low and very high trampling intensities.



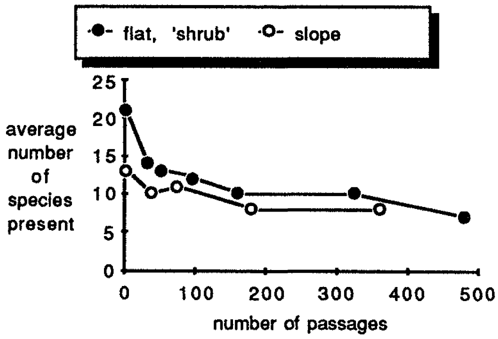


Figure 3.7. SR relationships: passages and plant species numbers.

There is an evident decrease in the number of species present with increasing trampling intensity. This result agrees with the findings of Goldsmith *et al.* (1970) and Liddle (1973), although the decrease shown by Liddle is much less conspicuous. The decrease in species number is much less conspicuous than those for the vegetation parameters in

* Throughout the text scientific names will be used mainly. Appendix A contains a complete list of scientific and English names of plant and animal species.

figure 3.6. Taking into account that identification of all different species requires rather experienced botanists, species number SR relationships seem only suitable for carrying capacity determination if the species spectrum is one of the objectives of the manager. The same holds for the number of invertebrate animal species (insects, spiders, woodlice, etc.); adequate identification of all species would require a team of specialists. Figure 3.8 shows some results for such "mesofauna" as produced by two different methods for collecting the animals (after Littel, 1974).

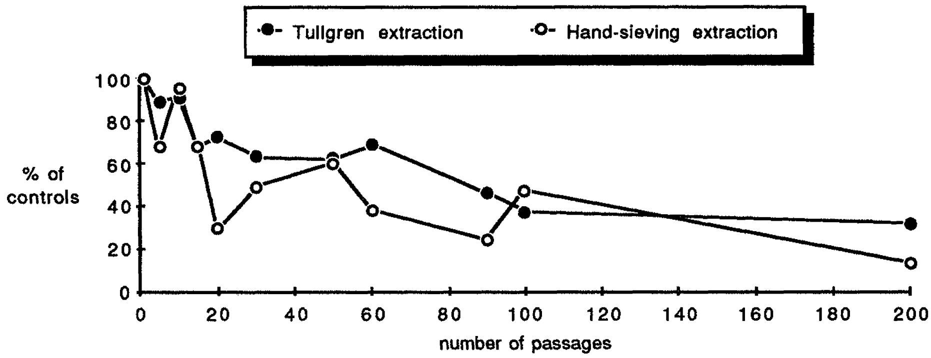


Figure 3.8. SR Relationships between passages and invertebrate animal species numbers, based on two different collection methods. Data are expressed as relative to controls (=100%).

Comparison of fig. 3.8 with fig. 3.7 shows that animal species numbers decrease more rapidly than plant species numbers do. This agrees with the results of Duffey (1975) who reports a decline of 50% of animal species numbers after 120 "treads" (=30 passages).

Almost all of the hundreds of plant species and thousands of animal species present in dune ecosystems are not suitable for our ends. Most of

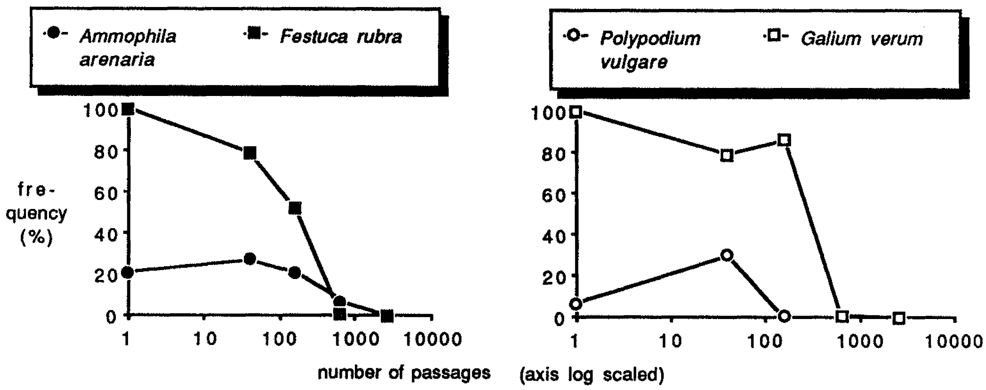


Figure 3.9. SR relationships between passages and percentage frequency (=presence) of four plant species (after Hylgaard & Liddle, 1981).

the species are rare or occasional, they are often inconspicuous or difficult to identify. They should therefore be used as indicators only in spatially limited situations. Rare plant species are often at the edge of their geographical distribution or suffer already from other impacts than trampling. The same holds for animal species.
SR relationships at the **species level** may be assessed by using different parameters: presence of the species, numbers of individuals, spatial features (height, cover, volume) and behaviour (of animals). Interestingly, almost no experimental documentation on SR relationships at the species level exists in literature, except for clear contrasts between "response" and "non-response" situations.
As regards plant species, presence is only a good parameter if a large number of samples are taken. This holds in particular for occasional and rare species. Figure 3.9 shows some results of Hylgaard & Liddle (1981) for dominant and occasional species in dune heathland in Denmark.

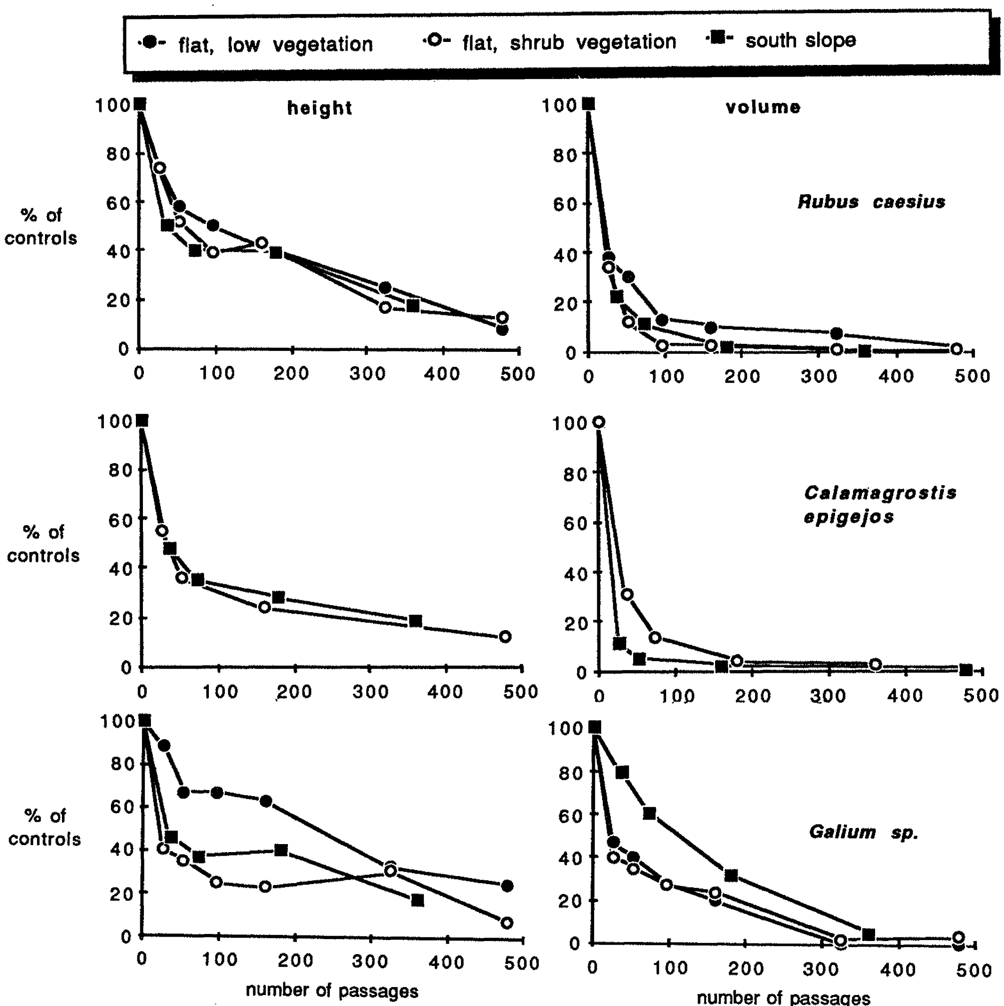


Figure 3.10. SR relationships between passages and height and volume for three plant species.

These results suggest that only for dominant species clear SR relationships can be assessed. For occasional species the response pattern is difficult to interpret. This also holds for the parameter "number of individuals", as many species occur in a clustered rather than a random pattern. Moreover, for many plant species (e.g. grasses growing in tussocks) it is difficult to tell what an individual plant is.
Height, cover and volume were already considered partly useful parameters for the whole vegetation (fig. 3.6). Figure 3.10 shows some results from our experimental research on slopes and in flat stands.
All species show a strong decrease for both height and volume, even at low trampling intensities. Volume, however, appears to be more sensitive, notably for *Rubus caesius* and *Calamagrostis epigejos*. *Galium* sp. is well-known to be relatively resistant to trampling (e.g. Haessler, 1954; Page *et al.*, 1985).

As regards animal invertebrate species or species groups, almost all SR research done refers to changes in **abundance**, i.e. the numbers of individuals present. Most research focuses upon the contrasts between high and low trampling intensity impacts, rather than on assessment of impacts for a range of intensities. Figure 3.11 shows some results from our research in the North Holland Dune Reserve (Littel, 1974; Boomsma & Van der Ploeg, 1976; Braat & Van der Ploeg, 1977).

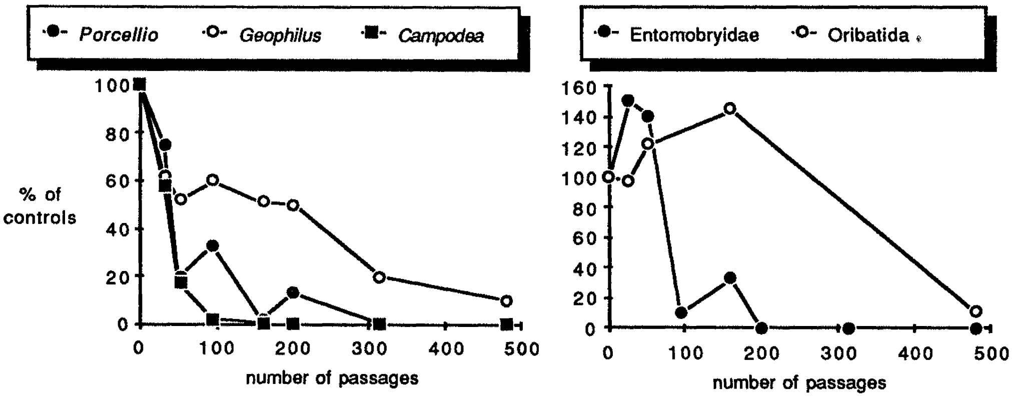


Figure 3.11. SR relationships between passages and abundance for five invertebrate animal species and species groups.

We have selected three sensitive examples (*Porcellio scaber*, a woodlouse; *Campodea staphylinus*, a bristletail; and the springtail family Entomobryidae) and two relatively resistant examples (*Geophilus* sp., a millipede; and the mite order Oribatida). The results indicate, however, that all five species (groups) almost disappear at high trampling intensities. This agrees with the results of Duffey (1975) who reports a comparable decline for 17 out of 21 beetle species, five out of six spider species and all four woodlice species.

Duffey found stable or increasing numbers for larvae of true flies, for earth worms, for one abundant beetle and for one abundant spider. This agrees with our findings (Boomsma & Van der Ploeg, 1976), and we have added millipedes to this list.

Finally, the recreational activity "walking" may also disturb larger animals like birds and mammals. Reviews have been given by e.g. Van der Zande (1984), Den Hertog (1985) and Hammitt & Cole (1987). Much research has been focused on assessing flight distances as a measure for sensitivity of animals. However, as regards our interest in SR relationships concerning capacities for multiple resource use, breeding density or breeding success are also appropriate.
As indicated by Van der Zande (1984), this type of research meets large methodological difficulties as regards the assessment of a stimulus as the cause of a response. Yet his studies are certainly convincing about this causality for a number of bird species.

Discussion

SR relationships are useful in understanding how a part of a natural resource is being affected by a human activity. The above examples have shown that for one specific stimulus, trampling as a consequence of recreational use of a resource, very different SR relationships can be assessed. Thus, at a certain (modest) level of trampling intensity, the resource ecosystem shows numerous changes in parameters, varying from local eradication of some plant or animal species to an increase in numbers or volume for other species. Selection of the most sensitive species (if we get to know which species that is, at all) as an indicator probably results in a carrying capacity that is almost non-use. Selection of general parameters like soil characteristics or total vegetation volume would possibly lead to loss of many species, as the most resistant ones would take over without substantial change in the mentioned indicator parameters.
Usually multiple use exerts many different stimuli and, within a resource area, there are many receptors that all may respond differently. Even if we could manage to know about all these separate relationships, it would be extremely difficult to build a (mathematical) framework to analyse and to predict impacts.
In view of the above, there seems no better way out than to select a small number of indicators that are not too sensitive (unless the management aims tell us otherwise) but that also do not mask substantial changes in the resource ecosystem. Such indicators should be measured in the whole area, in order to avoid the fallacy of restricting use because of locally intensive use. Such is obvious for recreational trampling; parameters may fall to zero on paths, but this is no serious problem as long as they do not do so beyond paths *and* provided that the path network does not cover a major part of the area surface.

In all cases the interpretation of this complexity remains very difficult. We should therefore consider the opposite approach: change the management and find out what are the differences. We shall return to this subject in the next paragraph and also in the Chapters 4, 6 and 7.

Yet, if we would *disregard* stimulus-response relationships because of the complexity indicated, we would make a serious mistake. Probably we would observe changes in the resource and would take haphazard measures to stop those changes. Thereby we would possibly "impinge on innocent use forms" while neglecting the use forms that should be regulated.

Recovery

Recovery refers to the ability of a natural resource ecosystem to regain its former balance, position or composition after disturbance. The word *regeneration* is often used as regards the recovery of an organism or a group of organisms (e.g. vegetation); it is also being used in soil science. *Reversibility* refers to the question whether a resource that is almost depleted or an ecosystem that is almost destroyed, but is left alone after that disruption, is able to recover.
After disturbance, organisms can regenerate. This is most clear in plants where growth by photosynthesis counteracts impacts. But also soils can be said to regenerate. They erode or leak out in time, but these processes may also revert a disturbed soil to its original state a good deal. Such regeneration also takes place during disturbance. In figure 3.4, the "positive" stimulus was partly considered as "natural growth" of an organism or a population. Regeneration becomes most clear, however, after the disturbance has ended.
As regards management, an important question is how much time the process of recovery will take. Hence we focus on the terms "recovery time" or "recovery rate" (i.e. recovery over time). If recovery time is infinite, the resource or resource component cannot recover anymore. In this case the term "irreversible resource depletion" is used. This is, of course, a "worst case"; usually the management will try to confine impacts to recoverable situations. But even in such situations recovery rates do not always equal natural growth rates. Abiotic conditions, for instance, may have changed so considerably that recovery of a plant species takes more time than explained by the growth rate of that species. In order to understand the seriousness of any impact, it is important to get knowledge about the recovery time, particularly in multiple use cases where part of the resource ecosystem is being damaged. Such damage affects demand-supply relationships of other use forms than the particular use form that exerted the damaging influence.

Regeneration power (also called resilience, robustness) of ecosystems can be very large. Dynamic ecosystems (e.g. coastal ones, because of dominant

impacts from the weather and the sea) are a good example; the environmental factors influencing such ecosystems are often dominant to any impact by human activities. In such cases only very severe disturbance ("break-down") is to be monitored cautiously.
As regards periodicity of stimuli, in many cases the system will be able to recover in periods of low human activity levels. An example to be given in Chapter 6 is the impact of dewberry picking in the dunes. In many areas the response to this stimulus is only visible during and just after the period of berry picking (August and September). In the next year, almost all traces of this impact have vanished. However, in the case of paths created and maintained by continuous (although maybe incidental) trampling, recovery time may tend to infinity because the systems properties have definitely changed locally.
In areas where sustainability of multiple use is a major objective, the manager should be well informed about stimulus-response-recovery relationships. Therefore we shall deal with the technical aspects of this subject in some more detail.

Basic features

Just like SR relationships, the possible process of recovery in time can be expressed by the three alternative curves already shown in fig. 3.3 and adjusted for recovery in figure 3.12.

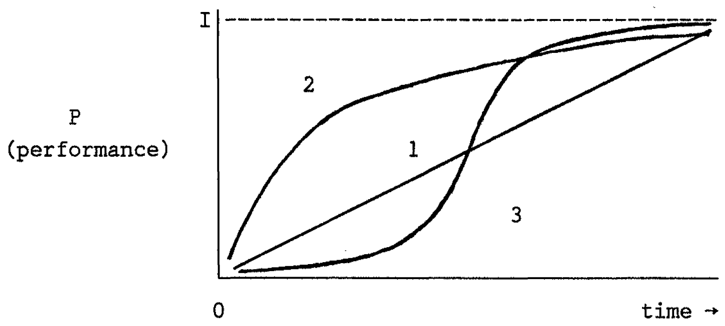


Figure 3.12. Possible recovery patterns over time.
I = initial performance level.

Recovery can be described with a linear (1), a hyperbolic (2) or a sigmoid (3) curve. Curve (2) is considered to represent resource indicators that recover relatively fast, approximating the initial performance level (I) fairly soon. This recovery pattern may be applicable to plant or animal species with a short lifespan and good colonizing power. Recovery of species with a long lifespan that are no good competitors in colonization may be best approximated by the logistic growth curve.
I is determined by properties of the indicator and by environmental characteristics of the site. If the latter have not changed since the

disturbance started, I will approximate the initial level indeed. In most cases, however, various environmental factors will have changed (e.g. by the same disturbing activity) and therefore the indicator will stabilize at a performance level somewhat different from I. In some cases the performance level of one plant species may even exceed the initial level because other plant species have a longer recovery time. Such information is very important if the management is aimed at particular species or other site characteristics.
Although the mathematical models for the three curves of fig. 3.12 basically differ, there is one simple sigmoid model that "mimicks" all three:

$$P = I / (1 + c * t^n)$$

where P = performance level of the indicator
I = initial performance level of the indicator
t = time
c and n are coefficients.

The coefficients n and c indicate differences in recovery patterns. The regeneration power is denoted by n. It is counteracted by c, standing for competition or colonization abilities. If c is very low, the sigmoid process (3) in fig. 3.12 will result. If c is high, the hyperbolic curve (1) is mimicked.
Although sigmoid models seem elegant explanations of real-world processes, we agree with the doubts of Majone & Quade (1980) in trying to apply them always and everywhere. Particularly in cases where a comprehensive data set is lacking, other models than sigmoid ones may show a better fit to the data. In such cases, an unpretentious description is needed.

Measuring and understanding recovery

The aspects of a resource which are being used in a multiple use situation determine how recovery should be measured. If, for example, the presence of a certain plant species is demanded, we may measure presence, frequency or cover. If only the flowers or fruits are being used we may record abundance of generative parts. Usually, however, we have to combine very different measurements. These can be categorized as follows:
1) soil properties as fundamental conditions for organisms,
2) plant or vegetation indicators like cover or species number,
3) fauna indicators like breeding success of certain species, or species number.

Hylgaard (1980) also mentions production of species, reproductive patterns of species and interrelations of plant and animal populations as important aspects of recovery.
Recovery times for all these variables may be very different. There is no use in trying to combine them into one resulting variable. Rather we may choose variables at the end of a cause-effect chain, e.g. animal species

that are restricted to a specific vegetation type which, in turn, is dependent on particular soil conditions.
Measuring specific variables to assess recovery requires understanding of the processes involved. We already mentioned "regeneration power" as an important phenomenon. But we must also keep in mind that the ecosystem itself is changing (succession) slowly during the recovery period. If we neglect such processes, we might misinterpret recovery data easily.

Some examples

Recovering is much less well-documented than SR relationships. Almost all publications refer to short term recovery (less than one year) or to estimated recovery times (e.g. Willard & Marr, 1970; Grabherr, 1982). The illustrations of recovery in this paragraph are therefore more succinct than those of SR relationships. Again we shall focus on experimental field research on recovery from trampling. Recovery in real world situations will be dealt with in Chapters 6 and 7. Again the majority of the examples comes from original experimental research in the North Holland Dune Reserve, done from 1973 until 1986. Part of this research has already been reported (Bouma & Van der Ploeg, 1975; Van der Linden & Van der Ploeg, 1982; Leltz, 1986).*

As regards **soil parameters**, figure 3.13 shows recovery data from the NHDR research for soil penetration resistance in flat stands (A) and bare ground surface on slopes (B). Short-term recovery from soil compaction

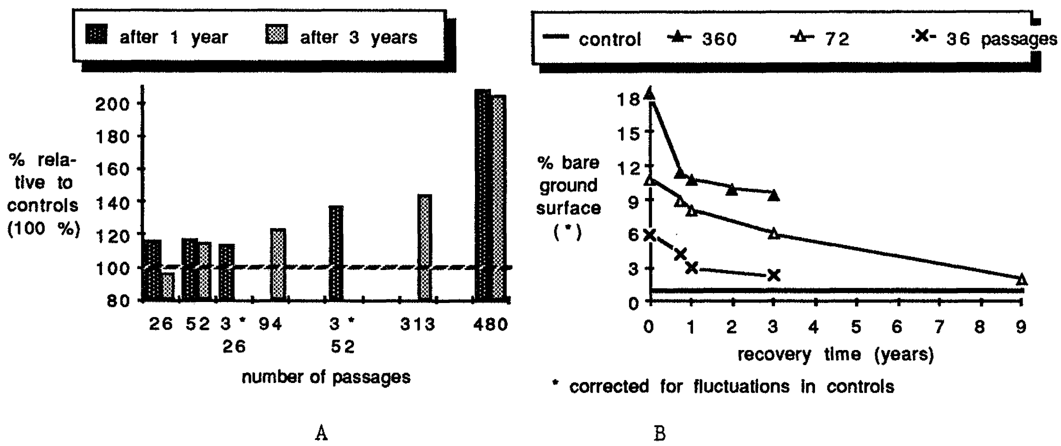


Figure 3.13. Recovery data after various trampling stimuli for soil penetration resistance in flat stands (A) and for bare ground surface on slopes (B).

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* Part of this research has been carried out with the help of students of the Free University. I particularly acknowledge the contributions of Ad Littel, Leon Braat, Hans ten Cate and Georgette Leltz.

only occurs in lightly trampled stands. High intensity of trampling results into severe soil compaction that is almost not lessened after three years at least (fig. 3.13.A, right-hand side). The extent of bare ground surface decreases more rapidly, most probably because of rapid colonization by certain plant species. Here again, light trampling intensities recover relatively fast.

Recovery data for average **plant species numbers** are shown in figure 3.14 for flat stands (left) and for slopes (right).

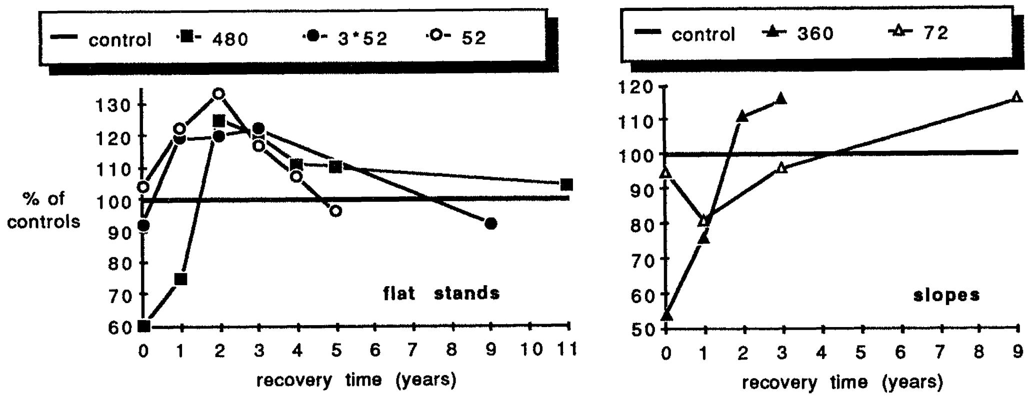

Figure 3.14. Recover data after various trampling stimuli for average species numbers in flat stands and on slopes.

Species numbers appear to recover fast (within a few years) and even to exceed numbers found in control stands. Probably the reduction of the standing crop of the original vegetation and the partial destruction of dead vegetation (the "litter layer") enables several species to colonize the stands. After some years, however, the number of species in previously trampled stands declines and approaches the control situation. On slopes (right-hand side of fig. 3.14) tendencies are more difficult to explain, but this is almost completely due to the presence of seedlings of various species in most of the stands (data having been recorded near the end of August each year).

In figure 3.10 we have shown SR relationship examples for three **plant species.** Recovery data for the same species are shown in figure 3.15, giving two examples for heights and two for volumes. Recovery after modest trampling during one year (the "52" and "72" stands) may take some years but it happens. Recovery after three years of modest trampling ("3x52") has also been established except for *Galium* (Page *et al.*, 1985, suggest that its performance success depends on the absence of cover by grasses for its performance success). Recovery after heavy trampling (the "360" and "480" stands) is uncertain; in most cases shown, no recovery in terms of gaining control levels has been assessed. In the case of the flat stands, one stand had been actually changed from a "shrub" stand into a "low vegetation" stand. Generally, recovery takes

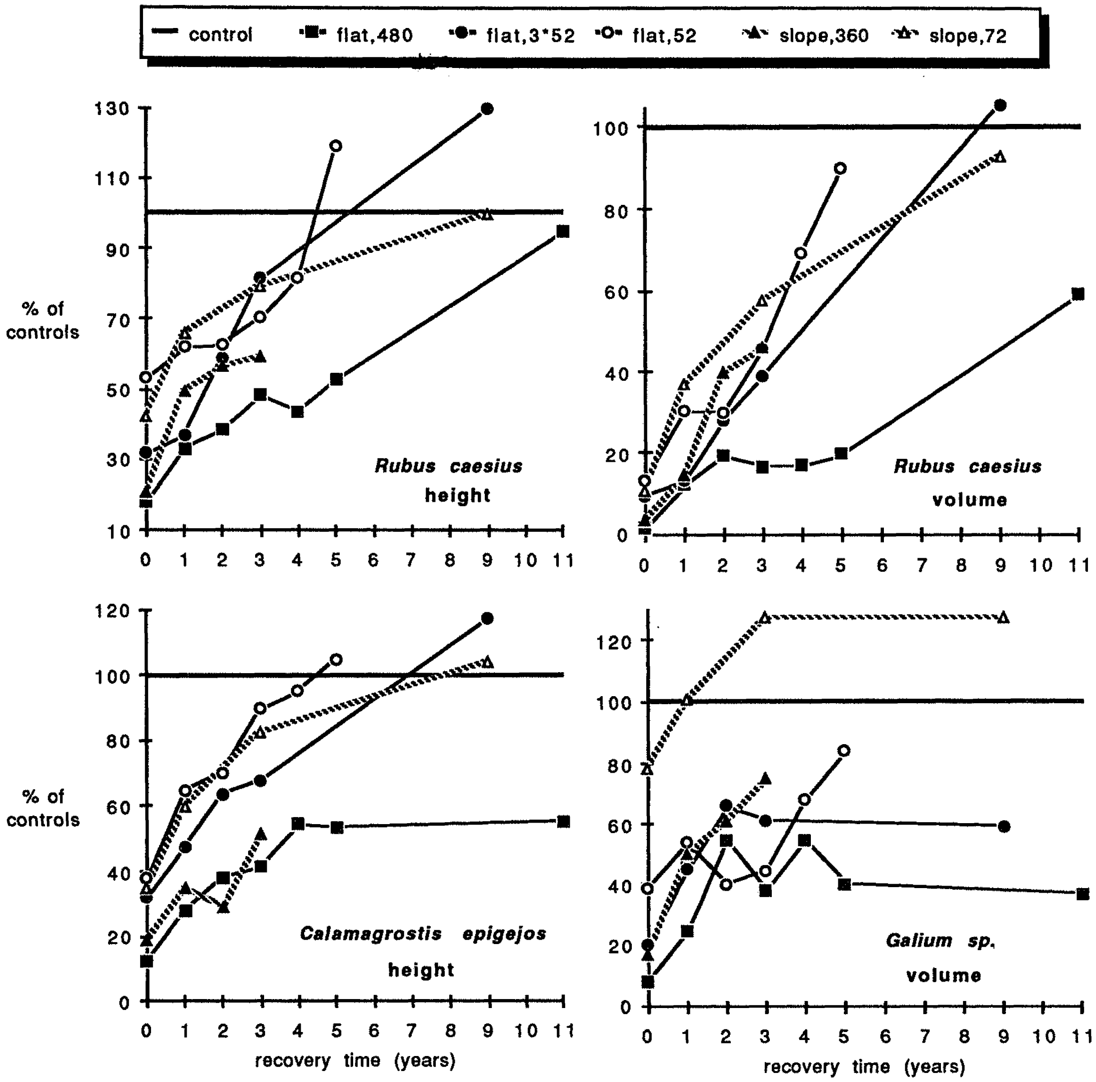

Figure 3.15. Recovery data after various trampling stimuli for three plant species. Left: heights; right: volumes.

at least some 4-5 years, even in modestly trampled stands. This even holds for stands trampled lightly (26 passages) during only one season (data not shown here).

Two contrasting recoveries seem to exist now: the relatively slow decrease of bare ground surface against the rapid increase of cover and volume. This contrast is explained by the change (as a result of trampling) in cover by **dead vegetation.** This "litter layer" often prevents extended cover by living plants in undisturbed vegetations. Its (partial) removal or compaction by trampling enables many species to extend their cover. After some years litter has accumulated again and counteracts further recovery.

These recovery data do not include recovery by means of additional planting, sowing or other management. These actions are reported on by Liddle (1973), Pizzey (1975), Bayfield (1980), Harrison (1981), Goldsmith (1983) and many others, and are equivocally considered useful.

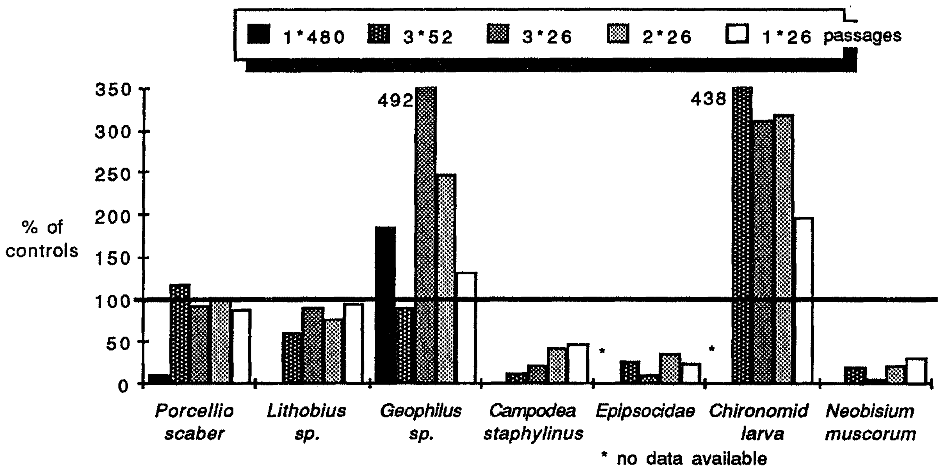

Figure 3.16. Recovery data for invertebrate animal species and species groups after various trampling stimuli. Recovery time for "1x480", "3x52" and "3x26": **1 year**; for "2x26": **2 years**; for "1x26": **3 years.**

Finally, we show recovery data for the abundance of a few **invertebrate animal species** in figure 3.16. The bristletail *Campodea staphylinus*, the booklice family Epipsocidae and the pseudoscorpion *Neobisium muscorum* have not recovered from the stimuli in any situation (possibly because these are very small animals that may need several years to recolonize trampled stands). Therefore they may be considered sensitive species (groups) that could well be used as indicators. The woodlouse *Porcellio scaber* and the millipede *Lithobius* sp. recover soon after termination of the trampling, except in the case of heavy trampling (480 passages). The millipede *Geophilus* sp. (which already appeared not sensitive in terms of SR relationships, see fig. 3.11) may even profit from the changed habitat conditions. This certainly holds for Chironomid larvae (non-biting midges). These conclusions are in accordance again with Duffey (1975) and Boomsma & Van der Ploeg (1976).

Recovery and continuous multiple use

Even if a certain activity in an area would cease (at least temporarily), other use forms would continue to exert influence on the resource. Recovery may strongly be influenced by this. Reversely, there is little use in stopping certain activities if the resource aspect in focus is being mainly affected by other use forms. Sometimes such decisions are easily made, e.g. to restrict horse-riding because of soil erosion. However, retardation of recovery from trampling because of changes in the groundwater level (by extraction for water-supply) would be much harder to assess. The same holds for a combination of recreational trampling and cattle or sheep grazing (and trampling). Conclusions about recovery from one stimulus should thus take into account impacts from other stimuli.

Discussion

Recovery of ecosystem components from impacts often takes more than one year; in extreme situations (e.g. high trampling intensities) recovery time may be expressed in terms of decades or even centuries (Willard & Marr, 1970). In such cases, part of the resource ecosystem cannot be used in desired quantities of demand by other use forms for a long time; conservational use is the first and most affected use form, but, for example, also productive use forms (grazing) may suffer from long recovery time caused by recreational impacts.

Information on recovery is a necessary complement to information about use impacts by means of SR relationships. The examples shown indicate that ecosystem parameters which are sensitive for trampling may recover relatively soon after termination of the impacts. The reverse may also be true, as shown for *Galium* (see also Page *et al.*, 1985).

The above examples show a wide variety of recovery patterns for different parameters of the same ecosystem (a dry dune slack). The same conclusion can be drawn for most other research done (e.g. Liddle, 1973; Hylgaard, 1980; Grabherr, 1982; Studlar, 1983). Hammitt & Cole (1987) state that recovery rates are more variable than impact rates because they are more dependent on environmental factors. Recovery rates for a particular ecosystem type appear to differ from one area to another (see e.g. Harrison, 1981, for grassland ecosystems) but rates can also be highly variable in different ecosystems within the same area.

Recovery from impacts by other use forms is usually stimulated by management. Such recovery will be discussed in Chapter 4. In the case of unassisted recovery, environmental factors like climate again determine the rate of recovery (see e.g. Bayfield *et al.*, 1984).

Recovery thus appears to be as complicated as SR relationships (and certainly in multiple use situations), be it in a different way. On page 49, we proposed an opposite approach: change the management and find out what are the differences. Termination of (experimental) trampling is such a change, and the results give some (but not unambiguous) indications of improvements of ecosystem qualities. As no experimental research has been done on the effectiveness of partial stimulus termination on recovery, such research can be advocated; monitoring recovery, however should be done during several years at least. Meanwhile we must draw on information from real-world situations where shifts in the management have been monitored.

A simple model for carrying capacity

The information on SR relationships and on recovery inevitably leads to the conclusion that, if the concept of carrying capacity can be made operational at all, capacities can only be assessed for particular use forms and particular resource ecosystem components. Any attempt to assess capacities for multiple use and representative ecosystem properties would fail because of contradicting data and also lack of knowledge. However, the information shown above (and also from Chapter 2, as regards use forms) certainly allows for a tentative, very simple design of a model for a dune area that may be useful to understand what is happening. This simple design is shown in conceptual format in figure 3.17.

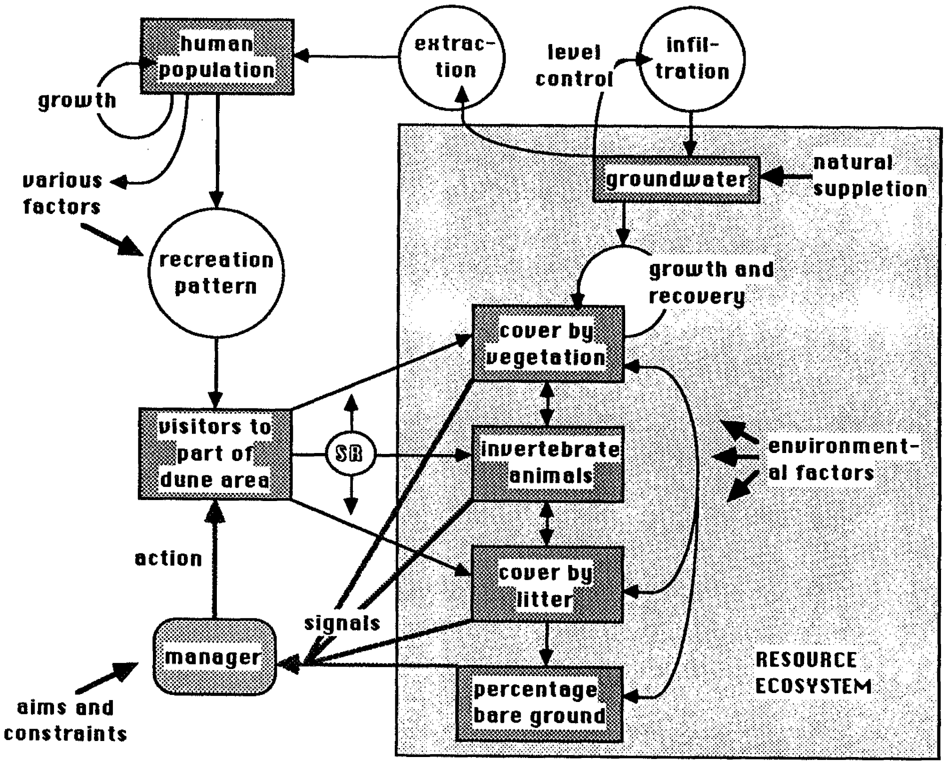

Figure 3.17. Conceptual format for a simple trampling impact model for a dune area.

This format contains three use forms: groundwater extraction for water-supply, outdoor recreation (aggregated to "visitors") and conservational use. Water production and recreational use are supposed to be determined by the human population, its growth and its preference patterns ("various factors"). Groundwater levels influence cover by vegetation. Visitors influence vegetation, animals and litter but these ecosystem components are also influenced by environmental factors. The ecosystem components mutually interact. The manager gets signals about the ecosystem by means

of monitoring and, after considering aims and constraints, may decide to regulate visitor intensity.
In such a format, SR relationships can be used to define the impact of different use intensities on ecosystem components. Information about recovery is useful to define changes in these components over time.
As an example, we have built a simple simulation model based on the above design, using the computer programme STELLA. For reasons of simplicity, we have only introduced part of the variables from fig. 3.17. We have fixed the number of visitors (and thereby the intensity of trampling) in order to make output comparable to experimental trampling intensities of 36 and 72 passages per year, during four years. Figure 3.18 shows two simulation outputs for both trampling intensities. The model specifications can be found in Appendix B to this book.

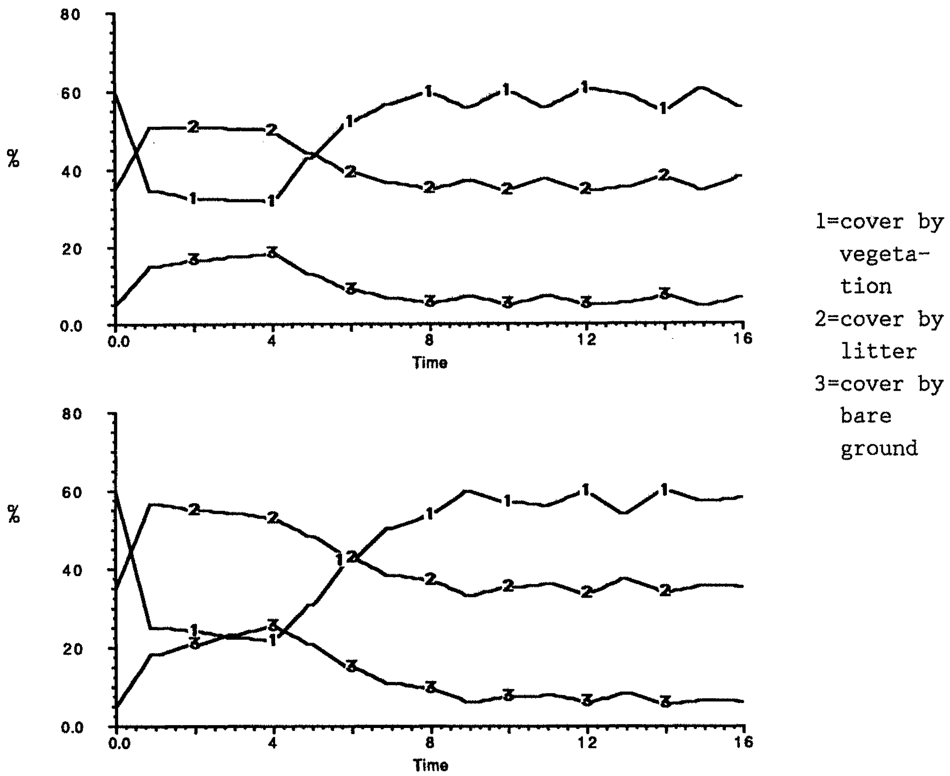

Figure 3.18. Simulation results from a simple trampling impact model for light (above) and medium (below) trampling intensities.

Although the trends do not closely resemble the field data shown in fig. 3.5.B, 3.6, 3.10 and 3.15, their general patterns compare very well. It is thus expected that a refined model could fit to field data. The present data shown in this chapter, however, do not yet allow for such refinements. In Chapter 4 we shall return to this model, including visitor management there.

Evaluation of the capacity concept

In Chapter 2 we have concluded that at least one use form, outdoor recreation, is less predictable than other use forms. The examples in this chapter show that the response of the resource is also hard to predict as many components of resource ecosystems show different responses to stimuli. At first sight this leads to the conclusion that growth/consumption ratios for resource ecosystems are hard to define and that capacity is predominantly a semantic concept that can hardly be made operational, particularly in case of multiple use.

Yet the trampling experiments show that in the case of high intensities of trampling (the "480 passages" examples) several ecosystem components do not recover within ten years. We cannot conclude that this implies an irreversible change of the ecosystem but this trampling intensity does not seem "sustainable over time" either. On the other hand, we have seen that prolonged modest trampling during three years (the "3x52" examples) certainly allows for recovery within ten years, or much less, and may therefore be sustainable to a certain extent. We may then have to sacrifice some vulnerable species, at least during the period of use and some years after.

The combination of SR relationship information and recovery recording thus can tell us something about the range of stimuli intensities within which the capacity level could be assessed. Yet we must be aware of large differences in responses and in recovery rates. Hence capacity levels will differ according to the choice for more or for less sensitive components (indicators) of the resource ecosystem. SR relationships and recovery data are useful here as well because they inform us about sensitivity.

Trampling experiments only allow for capacity statements concerning the experimental stimulus. The real-world trampling stimulus by visitors to an area may be very comparable but the composition of it is certainly not. Few playing children may exert more "trampling stimuli" than hundreds of adults going out for a walk. Thus the translation from experimental stimulus intensities to actual stimulus intensities by use forms may be very difficult without comprehensive monitoring of both use and response.

More generally, trampling stimuli are difficult to compare with other recreational use stimuli. Horse-riding, for example, does much more damage to the ecosystem than human trampling, as we shall see in Chapter 6. Sailing has impacts on breeding birds but passengers going on land exert completely different stimuli, as will be shown in Chapter 7. Wildlife interest may show a random trampling pattern that is different from recreational walking or from dewberry picking. Thus trampling is not the same as trampling, and recreation is not the same as recreation, as regards both SR relationships and recovery rates.

Even if we would know capacity levels for recreational use, we cannot

trust data from monitoring. Other use forms may have influenced the resource indicators monitored, and any conclusion about an indicator that seems to be too much influenced can only be drawn if for those other use forms also SR relationships and recovery rates are known.
Conceptually we would like to design an experiment with multiple stimuli to assess the resulting response. Reversely, it is most important to detect to which impact(s) the response is predominantly directed. Experiments with variations in stimuli might help us to understand this. Ultimately the goal would be to find out which stimulus (or assembly of stimuli) intensity induces an impact that can be "neutralized" within an acceptable period by regenerating forces.

Most of the above seems to be based on the implicit value judgement that the *status quo* is "good" and that changes away from that are "worse". Indeed this is the position held, as long as there is no explicit statement made about multiple use aims. If, for example, conservational use would get more attention, the present *status quo* might be not good at all. There might even be situations where an "upgrading of natural values" might benefit both conservational use and and most other uses. Clearly this is an optimization problem that must be analysed in more detail than is possible here.

The main problems about the capacity concept thus regard the assessment of resource availability over time and the way to interpret information about the resource. The performance of the resource under stress of multiple use cannot be assessed without almost perfect information about the impacts of all use forms. But even then internal relationships within the resource ecosystem have also to be known for the assessment of resource performance. Such information can only be acquired at high costs in terms of labour and money.
We therefore conclude that in the multiple use situations we focus on, the capacity concept can be used in a conceptual way but it can seldom be operationalized. Yet constituents of capacity like SR relationships and recovery may provide valuable information for defining aims, for rough approximations of acceptable use intensities and for interpretation of monitoring results.
We thus adhere to the capacity concept, without the illusion that it can be operationalized. Management of multiple use needs some denominator to decide upon, and "sustainability over time" may be not the worst to choose.

4. MANAGING MULTIPLE USE OF NATURAL RESOURCES

This chapter introduces a number of aspects concerning the management of natural resources that are in multiple use. Aims (notably as regards spatial planning) stated by various authorities are discussed as they delimit objectives of, and actions by management. Sustainability of use belongs to the important aims and objectives. Management is constrained by ecological, by social and by budget limitations, and also by lack of appropriate knowledge about interrelations between aims, objectives, use patterns and resource characteristics.
Several types of instruments for management are reviewed, with major attention to regulation of recreational visitors by entrance regulation and by zoning. External conditions for use can be influenced but the manager has no control over the effectiveness of that influence. Ecological management instruments can also be applied, but "doing nothing" is often a good choice.
Management effectiveness is influenced by conflicting aims for area use and by external impacts of management actions. Integrated management-response relationships are discussed for their relevance to management. This chapter concludes with some examples of measures of effectiveness.

Managing natural resources

If use of natural resources would be a free choice for any person, such resources would probably vanish soon in densely populated countries like the Netherlands. Therefore regulation of use is often needed. Depending on the nature of the resource, the use and the ownership status, regulations are being established and implemented by various authorities, by private owners or by managing bodies. Regulation of use and care for the resource is effectuated by management.
"Management has to give direction to the institution it manages. It has to think through the institution's mission, has to set its objectives, and has to organize resources for the results the institution has to contribute." (Drucker, 1985, p. 17).
"The manager has to be a craftsman. His first duty is, indeed, to make his institution perform the mission and purpose for the sake of which it exists - whether this be goods and services, learning, or patient care. But this is not enough. Any institution exists for the sake of society

and within a community. It, therefore, has to have impacts; and one is responsible for one's impacts." (Drucker, 1985, p. 18).
Multiple use of natural resources may easily lead to overconsumption and even depletion of the resource, particularly if the use forms are not interdependent and if the resource is a common property resource (Walters, 1986; see also Chapter 2). In such cases, the manager is, to a large extent, the steward of both users and resource. The previous chapters have indicated the possible complexity of user-resource interactions. The manager has to monitor such interactions and has to decide upon action if the aims of his institution are not met.
In Chapters 2 and 3 we have analyzed demand and supply at the *area* level mainly. Hence we also focus on the area level as regards management issues. We shall concentrate on multiple use of areas that are, at least partly, public land. Most attention will be paid again to "minor" land use forms like outdoor recreation and nature conservation. For reasons of simplicity we shall denote "management" and "manager" as single entities, neglecting the fact that they are usually much more complex.
In terms of the definitions quoted above, the "institution" is the authoritative body governing the area. Its "mission" is to maximize sustainable welfare benefits from the area, subject to constraints on certain qualities. One of the "resources" for this is the natural resource area itself. The mission is dependent of exogenous aims and constraints, management objectives are mostly endogenous.

Aims and objectives for multiple use

In reviewing aims and objectives for multiple use of a natural resource area we may distinguish several levels of abstraction which compare to spatial aggregation levels.
Regarding the *national or regional level*, aims are usually derived from or dictated by policies. Such policies are stated in general terms, for example denoting an area as "important for outdoor recreation" or "important for nature conservation". Such aims are exogenous *data* for the area manager; usually he is not able to influence them. Such aims, however, determine the spectrum of use forms important for his area.
Sustainable use of the area is also an aim that is imposed upon the management. Policies generally do not account for depletion of the resource but implicitly take the line that use is sustainable. It is up to the manager to achieve this.
At the local or *area level*, management objectives become more specific. Use forms as well as resource characteristics can be defined in more detail; consequently, objectives can be formulated in terms of the extent to which demands should be satisfied (e.g. on a year-to-year basis within a long-term perspective).
At the sublocal or *site level*, management objectives can be very

straightforward. Three different types of objectives may be distinguished here:

1) objectives as regards the *actual use* of the site (numbers of visitors, numbers of trees cut, volume of freshwater extraction);
2) objectives as regards the *design* of the site (in regard to regulations of use forms);
3) objectives as regards the *sustainability* of site use (in regard to preservation of particular characteristics of the site).

Figure 4.1 shows these different types of aims and their dependencies.

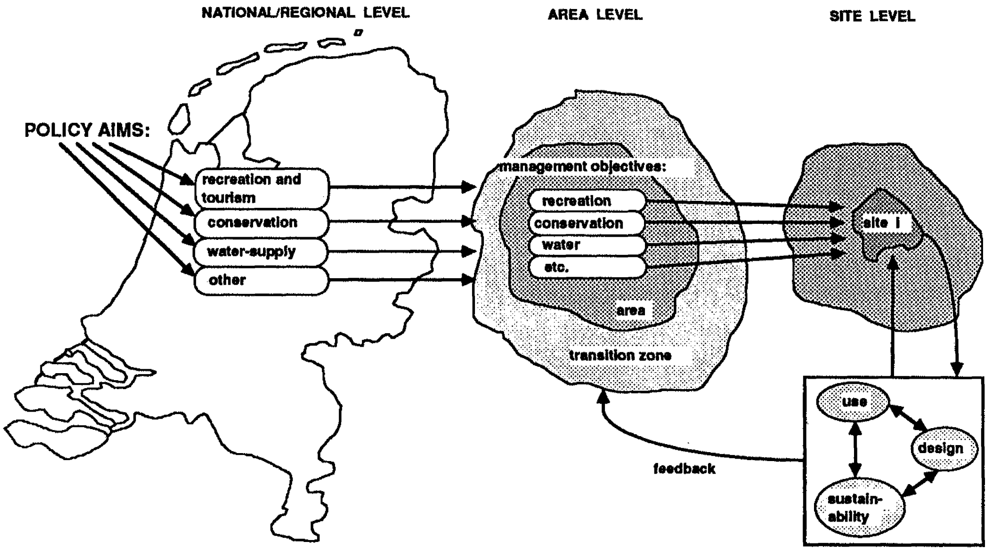

Figure 4.1. Aims and objectives for multiple use of an area.

The focal level of management decision-making therefore seems to be the area level. Policy aims for many use options have to be integrated at the area level into a consistent set of objectives, while from the site level information is obtained about use and sustainability. These information streams merge into three principal objectives at the area level:

1) to enable use as required by policy decisions
2) to optimize any use within the following constraints:
   * conflicts and exclusions should be minimized
   * any area characteristics that serve use purposes should be enhanced without disturbing stability of the resource
3) to ensure sustained use in consequence of the above.

We have defined *nature conservation* as one of the possible use forms. It is very important to have this definition in mind while considering area management. If an area is designed for conservational purposes, this means a use form which may exclude other use forms to a great deal. So we should not consider conservation as a counteracting force *against* "use" but merely as a competing use form in space, time, politics, management and budget.

Policies and area management in the Netherlands

As we have concluded in Chapter 2, the "economic market" where demand-supply relationships are displayed is not at all a free market. Even the private owner of an estate or a comparable area is not always free to decide upon the use forms to be permitted; managers of public lands are even much more confined to policy decisions. Apart from socio-cultural configurations that include a certain degree of market freedom, the population density of a country or a region is a major factor for the width of choice margins. Outdoor recreation, as a very widespread phenomenon, needs space which cannot be provided without retaining other use forms. But space for recreation cannot be bought or rented generally, so policy decisions are taken to ensure supply.

In the physical (spatial) planning of the Netherlands by authorities, three decision levels are relevant for area management. First, the "Structuurschemas" contain sectoral national spatial planning as established by the government. Second, the "regional plans" are established by provincial authorities in accordance with "Structuurschemas". Third, local "zoning plans" are established by local authorities after approval of the provincial authority.
"Structuurschemas" have been established for most of the important land use forms. In the scope of this book, the schemes for "Water-supply", "Outdoor recreation" and "Nature and landscape conservation" deserve most attention. The core of such a sectoral scheme is formed by the so-called "essential statements". They indicate spatial claims only for the use form considered in the scheme, and they commit the government to realize these claims.
As these schemes reflect the spatial aspects of demand from one use form only, for example outdoor recreation, spatial claims may be laid on one and the same area by many different schemes. Although these claims may be weighed against each other to some extent, their multiplicity may induce conflicts between aims for the area. At present, an integrated "second generation" scheme for countryside use (including agricultural use, recreational use and conservational use) is prepared. However, this does not include other sectors like water-supply, transport or town planning.
Regional plans usually take into account national policies, as expressed by several or all "Structuurschemas" and other documents. They blend such national options with particular regional and local situations and policy issues. Regional plans take the form of one resulting map (often 1:50,000) of the region on which all destinations are roughly designed, accompanied by many detailed maps and an explanatory text. Often contrasting claims for space are (politically) weighed before the final map is designed. Regional plans account for actual use forms but

also are real "plans" as they envisage shifts in land use.
Local zoning plans are the result of decisions about use of space on the local scale. They have to account for national and regional aims but also for ownership, existing regulations etc. A local zoning map is usually very detailed; it can be used in any legal conflict, in contrast to the other planning documents mentioned. Local plans reflect the present situation but also include approved plans for future use of space.
Multiple use areas, particularly the larger ones, may fall under the regime of several "local zoning plans". Sometimes the area is also covered by two "regional plans". Then the manager is confronted with a huge variety of use options, stated in different degrees of detail.

Finally, quite recently two national planning documents for the Netherlands have been presented: a national environmental policy plan (Anon., 1989) and a national nature policy plan (Anon., 1989a). Both plans are based on the philosophy of sustainable use of the environment and the natural resources of the Netherlands. Many natural resource areas are envisaged to constitute an "ecological principal structure", consisting of core areas, areas where natural values should be upgraded, and zones connecting these areas ecologically. The managers of such areas face a new variety of policy aims that have to be translated into management objectives. A third document, regarding national water management, will be published soon and will again contribute to the variety of aims.

Management objectives

The foregoing suggests that the manager of a multiple use area has predominantly the complex task of finding his way through all contrasting options from various authorities. Indeed the reconciliation of diverging aims into a sustainable configuration of use forms is a major objective. Usually, however, the manager will also strive for such satisfaction levels for each use form that all parties involved can realize their aims in a "reasonable" way. Therefore a second major objective is to manage the resource in such a way that use possibilities are optimized without leaving the sustainability principle.
A third major objective may be averting risks (Walters, 1986). Many resource managers show strong aversion to any policies or developments that involve risk. This attitude may easily lead to the formulation of objectives that retain some use forms (in a multiple use situation) as a safeguard for other use forms, even if there is no evidence that suggests to do so. Examples are strong restrictions on recreational use as a safeguard for forestry and also for conservation.
Specific management objectives for the area level and for the site level have already been indicated above. As any area differs from another as regards demand and supply characteristics, we shall not deal with such specific objectives in this chapter. In the Chapters 5, 6 and 7 some examples will be analyzed.

National Parks as a special case

In the Netherlands, National Parks are protected areas of at least 1,000 hectares where conservational use is the major use form, while outdoor recreation is the most important subsidiary use. Other use forms, if present at the time of establishing a National Park, are not enhanced and are often brought to an end in due time (Anon., 1975a).
This short description also defines the aims for National Parks: preponderance of conservation, some outdoor recreation (particularly the non-intensive and the non-resident use forms) and almost nothing for other demands. In practice, however, established use forms like agriculture, forestry, transport, water-supply, sea defence (dune areas) and intensive recreation necessarily influence National Park aims, dependent on the location of the area. At least in one case this has led to an advice to postpone the nomination of an area as a National Park (Anon., 1989b).
National Parks are nominated and established after a process of consultation and research. Most of such areas belong to the jurisdiction of several local authorities, corporate bodies like "polder boards" and "outdoor recreation boards", provincial authorities and various government departments. Naturally, each party cherishes its own aims and the nomination of a National Park may therefore take several years. The managing agency is charged to realize the compromise in terms of achieved conservation of a variety of species or of naturalness, numbers of visitors admitted etc. In National Parks the manager is often carrying out decisions by the governing body rather than formulating his objectives and getting them realized.
In comparison to other countries, for example the U.K., the National Park concept in the Netherlands is simple, as activities like agriculture, transport or residence are excluded as much as possible, unless they are compatible with the NP aims (e.g. some forms of agricultural use). But even then it is not at all easy to manage such National Parks in a way that most users are really satisfied. Therefore National Parks (and particularly those which are proposed but are not yet existing) are good examples of areas where multiple use issues are encountered.
Dutch National Parks cover a wide range of ecosystems and landscapes (e.g. dunes, salt marshes, heathlands, moorlands, woodlands and wetlands). For convenience we shall mainly give examples referring to coastal dune areas, but most of these examples are, *mutatis mutandis*, applicable to other ecosystem types.

Management constraints

As indicated above, many different parties may be involved in decision-making for multiple use areas. Many different aims result; these aims are constraints to the "decision space" of the manager. A few examples may

clarify this point as regards multiple use issues.
First, one of the aims for a National Park is to increase "natural richness". To achieve this, no species may be lost and new species should be enhanced to colonize the area. Often the non-present species are very sensitive to disturbance. Thus the manager has to be very strict towards any possible sources of disturbance, for example by rigid control of visitor pressure and groundwater level.
Second, another aim for NP's is to "enhance informal recreation in a natural setting". Many recreationists do not like to walk over large distances. Thus the outward parts of the area should be developed for such recreation. Visitor pressure, however, will usually inhibit natural developments, even disregarding the fact that most visitors do not like "rotting trees and messy underwood", both natural features of a woodland ecosystem.
If the area is relatively small, such aims cannot be reconciled. The manager then has to go for an option that sails between the Scylla of conservationists and the Charibdis of recreationists.

Ecological limitations

Even in a situation without contrasting aims and objectives, the nature of the resource sets limitations to management. The ecosystems that constitute the area consist of species and abiotic structures that are limited by external, "controlling" factors like climate and nutrient supply. Sustainability of use is often a case of respecting the "ecological margins". If part of a dune area is being eroded by concerted influence of visitors, rabbit digging and wind force, this part of the resource comes under threat of depletion. Reversely, the manager has to accept ecological limitations in admitting visitors to such an apparently vulnerable part of the resource.
The "power" of the resource to continue to supply goods and services (see Chapter 3) is an ecological problem that sets limits to management options. Often the factor "time" is decisive in this respect.

Social limitations

Managing actual use of an area is limited by the fact that use cannot be concentrated indefinitely. Directing all visitors to one specific part of the area would create congestion which would decrease the satisfaction of visitors. Moreover, use forms like conservational use practically exclude any congestion at all, as may be the case for wildlife interest use forms. Another social limitation is set by the "psychological" exclusion of use forms. Wildlife interest and conservational use, for example, do not allow much timber production or water-supply activities because these are considered incompatible.
Use patterns are therefore likely to be established not only on account of preferences of users and the area design by the manager but also

because use forms may be socially incompatible. It is important to be aware of such limitations to management activities.

Other constraints

Budget limitations often abort solutions to multiple use problems. Three categories of expenditures seem most relevant: salaries, design and building of facilities, and materials. As to salaries, management of the area needs maintenance and use control, apart from administrative work. Depending on the extent of the area all these costs may amount to a large sum. For some use forms (particularly outdoor recreation) facilities like car parks, playgrounds and litter bins have to be provided and maintained. Materials for maintenance of the infrastructure and for fencing parts of the area also claim part of the budget. Building and maintaining sea defence works and water-supply plants require large sums.
The monetary benefits from the area may vary according to policy and management decisions. Entrance fees, if charged (which is not intended for National Parks), may be a considerable source of income. The volume of water supplied is paid to a great deal by the consumers. In some cases timber production or benefits from grazing may be added to the balance. Activities like sea defence and conservational use, however, cannot be charged to a specific consumer (see Chapter 2) and must therefore be paid from national, regional or local budgets. The manager depends for this money on policy decisions which take into account many more claims than only his management claim.
Table 4.1 gives an impression of the costs and revenues as regards outdoor recreation (excl. campings, which made a considerable loss) and maintenance of a dune area of 4,800 hectares in 1986. Net costs of almost five million Dutch guilders are supplied by the province (60%) and by the managing agency itself (40%).

Table 4.1. Costs and revenues (in Dutch guilders) per hectare for outdoor recreation (excl. campings) and maintenance of a dune area of 4,800 hectares in 1986 (Source: Anon., 1987).

		Paid by	
	Total	Province	Management agency
Costs/ha	1368	932	436
Revenues/ha	345	313	32
Net costs/ha	1023	619	404

Finally, lack of knowledge about the interrelations between policy aims, management objectives and decisions, use patterns and resource characteristics are an important constraint on management options. Making mistakes may be expensive (in relation to the actual effectiveness) and may also induce problems in the relation between the manager and politicians or user groups. *"In dubiis abstine"* may be less expensive but embodies the risk of diverting from aims and objectives stated. Research and experiments can only help to increase understanding of the problem as a whole but almost never point to a single "optimal" solution.

Instruments for multiple use and resource management

Management cares for the resource itself and for its use. Resource management is a matter of ecological understanding; use management requires understanding of use patterns and their causes. Instruments for management can be deduced from these.
Three different categories of management can be distinguished here:
1) "resource use management" regarding the actual (multiple) use;
2) "external conditions management", regarding three different aspects:
   * "use condition management", regarding physical conditions *outside* the area which may influence actual use of the area;
   * "information management", regarding information about the resource and how to use it, directed towards society in general;
   * "exogenous influences management", coping with activities outside the area that influence it;
3) "ecological management" of the resource as an ecosystem.

Detailed analysis of these three categories would require another book. Moreover, such information is already available (e.g. Roelofs, 1975, Bakker *et al.*, 1979, and Ranwell & Boar, 1986, for dune areas; Warren & Goldsmith, 1983, and Green, 1985, for a variety of natural resource ecosystems; Mercer, 1979, Herbert, 1983, Edington & Edington, 1986, Hammitt & Cole, 1987, and Van der Meulen, 1987, on management of recreational use of natural resources; Addink, 1982, on a National Park in the Netherlands). We shall therefore only briefly mention some instruments that are relevant for a multiple use situation.

Resource use management

Resource use management intends to regulate intensities of use in such a way that resource use aims and objectives are attained. In multiple use situations, management is concerned with a chosen balance between the dominancy of each of the four use interactions listed on page 11: indifference, cooperation, competition and exclusion. The balance chosen is to be derived from aims and objectives stated for the use forms under consideration, under the sustainability constraint.
Use management is concerned with the users of the resource. We may distinguish two very different categories of users:
1) people *entering* the area to use it for recreational or conservational purposes;
2) people *working within* the area (also using artefacts) to use it for private or public ends.

As this book focuses on outdoor recreation, most attention will be paid to the first category: the "visitors". Visitor use can be managed by three major instruments: entrance regulations, zoning and information.

Entrance regulations influence the total numbers of visitors. Firstly, the *physical design of boundaries* (e.g. fencing the area, either by wires or by natural devices like dense shrubs) may restrict most of the visitors to entrance gates. In combination with the area road and path network this instrument is effective; it can, however, also be very costly. Another physical restriction is formed by the extent of parking lots near the entrances. This capacity is only relevant at peak days.
Secondly, *entrance fees* may as such inhibit many visitors to enter the area. The amount to be paid is often not really prohibitive, provided that it is comparable to, or lower than entrance fees for touristic attractions. A high fee for an area without recreational facilities or scenic highlights is prohibitive. A management problem is the checking of tickets. Both instruments relate to multiple use management as far as total numbers of visitors play a role.
National Parks in the Netherlands should have free access for visitors, partly because not all NP areas can be effectively controlled. Thus this instrument cannot be used for regulation of visitor numbers in NP's.
Selective access seems the most important regulation instrument to exclude particular visitor activities which, in the opinion of the manager, affect his chosen optimum for multiple use. Well-known examples are restrictions on smoking in forestry areas, prohibitions to play music, to leave paths or roads and to pick flowers in natural areas, speed limits to boats and also opening hours. Such selective regulations often include a complete ban of particular visitor use forms like horse-riding and transport by cars or motorbikes. Although such regulations are effective in the sense that offenders may be urged to leave the area, enforcement may be costly. A notorious example of this problem in many natural areas is formed by dogs that should be kept on the leash but often are not, thereby disturbing wildlife. In Chapter 7 we shall discuss the formally illegal use of watercourse banks.

Zoning is the establishment of a spatial differentiation into parts of an area that are destinated for different use forms, for different use intensities or for specific combinations of use forms and intensities. Zoning can also be applied in a temporal context, if particular use forms or intensities are to be restricted to specific periods (hours, days, seasons). Most of the access regulations discussed above can be considered as "external" zoning (outside the area) at the regional level, as they influence regional visitor patterns (see also fig. 2.2).
The *infrastructure* within an area largely determines flows and densities of visitors. The design of a network of roads, paths, horse tracks, watercourses etc. enables the manager to lead the visitors where he wants them to be, and also to separate different types of visitors if

this is desirable. A good quality of pavements appears to induce visitors to stay to the network; the same holds for the attractiveness of the road and path design (straight paths, for example, are often considered boring). A special case are the guided trails and tracks which are very popular, as many visitors do not like to move around without some "feeling of security".
The *location of facilities* is part of the infrastructure. Some types of facilities like restaurants, shops and visitor centres act as "honey pots", determining the spatial behaviour of a large number of visitors. But also simple facilities like lookouts, playgrounds, benches and even litter bins attract and therefore concentrate visitors.
Site restrictions act the reverse way, being intended to deconcentrate visitors. An often used restriction is again selective access, either spatially or temporally (e.g. access restrictions during the breeding season of birds); it is also being used to separate different visitor use forms, often in relation to objectives as regards use of specific aspects of the resource, and to separate use forms like recreation, water-supply activities and conservation.
Zoning is usually applied as a mixture of these instruments, in relation to the multiple use management objectives. Its effectiveness depends on the acceptation by visitors of the regulations and on the possibilities for control.

Information about the area and also about specific sites can inform visitors about the characteristics of the area and the acceptable use of it in various ways. Firstly, information stands at entrances have proven to be used very much. Secondly, a visitor centre may inform people about the area and the expected behaviour (Van der Linden, 1983). Such centres also provide the opportunity to introduce other use forms of the area to the visitors. Thirdly, information can be provided by local tourist authorities, regional or national user organisations (both tourist and conservation information).
"Good information and interpretation for the public engenders their understanding and support and reduces the level of vandalism" (Goldsmith, 1983). Although the latter claim has never been proven, the importance of the role of information and interpretation in guiding visitor behaviour is widely acknowledged (Green, 1985; Hammitt & Cole, 1987). Frost & McCool (1988) even demonstrate that well-informed visitors may view regulations as a way to enhance their recreational experience rather than detract from it.

Managing other users than visitors is an almost necessary consequence of multiple use. Use forms like water-supply, agriculture or forestry have no consumers in the area itself. Only producers of such services are found there. Their behaviour may interact with other use forms; also artefacts (e.g. buildings) connected with these use forms may influence or be influenced by other use forms. Therefore it is necessary to manage

such use forms in accordance with the overall area use objectives. If different use forms are managed by different persons or institutions, the situation is far more complicated but the same principle applies.
In some cases mutual exclusion is necessary. If dunes are used as a sea defence, one cannot allow high densities of recreationists eroding them. Reservoirs for water-supply are not meant for swimming. In many cases, however, use forms may go well together. Zoning of visitors can be used to provide sites for other use forms. Theoretically one could even think of a specific zoning plan for each use form.
People working in the multiple use area (next to the wardens) may also contribute information for management. They usually know the area very well (and mostly appreciate it very much). Knowledge about the resource and its use certainly does not depend on research only.

External conditions

We have already distinguished three major types of external conditions. The common theme for these conditions is that the manager is certainly able to influence them, but he has no control over the effectiveness of his influence.

Use condition management mainly relates to regional conditions that determine the use intensity of the area. As regards recreational and conservational use, the regional transport infrastructure, the availability of alternative areas and the abundance of tourist facilities at the local or regional scale mainly determine the number of visitors to be expected in the area under consideration. Conservational use is probably enhanced by low performances of these conditions, while the reverse probably holds for many recreational use forms. Productive use forms usually can be enhanced by a good transport network but are indifferent as regards the other conditions mentioned.
The manager of the area can certainly try to influence decision-making as regards these conditions, but he does not decide. Therefore he has to incorporate such decisions in his decision-making for the area itself, eventually changing the application of resource use management instruments considered in the previous Section.

As regards **information**, the manager is not necessarily confined to activities at the boundaries of and within the area. We already mentioned information by various organizations. Indeed the manager can design a picture of what can be expected from the area in terms of different use forms. This picture may certainly influence visitors and other users of the resource in their actual use pattern. The decision for use or non-use is not the manager's but is taken by the (potential) users themselves.

"Exogenous influences" are caused by activities outside the area, not falling under the jurisdiction of the manager. An actual example is acid deposition caused by factories, power-stations and vehicles often miles away from the area. A considerable number of resource ecosystem components may be influenced. The same holds for groundwater contamination, pollution with heavy metals, eutrophication with phosphorus and nitrogen compounds, and noise from outside the area. In all cases the manager can bargain for problem solutions but he will seldom be in a decision-making position.

Apart from the decisions on aims discussed at the beginning of this chapter, the manager is thus confronted with a number of events (regional planning, social preferences, regional and national pollution and disturbance) that he cannot regulate. Therefore the setting of management objectives does not at all guarantee their realization, and sometimes there may be reason to reset them.

Ecological management

For a huge variety of ecosystem and landscape types ample information is available about management of the existing situation and about upgrading natural values. To the publications already mentioned in this Section, we may add Haslam (1973), Anon. (1979b), Goderie (1986) and Van Amstel *et al*. (1988) as they refer to the management of dune areas and wetlands to be discussed later in this book. In this chapter, however, we are mainly interested in management instruments in multiple use situations.
A first observation is then that ecological management for conservational use objectives often almost excludes management for many other use forms. One of the best examples is ecological management for upgrading natural values of forests. This management implies that dead trees, branches etc. are not removed from the area and that no tree cutting or coppicing is allowed. Apart from this exclusion of timber production, only a part of the visitors will appreciate the resulting landscape. The reverse situation (sheer tree planting and cutting without any consideration for conservational or recreational interests) is also well-known.
However, we must immediately add that such examples are only found in areas which are managed for one dominant use form. Other use forms are then a by-product but are not important as regards management objectives. In areas with explicit multiple use management objectives, ecological management must strive for compromises in applying instruments. Some examples of such compromises are:

* modest, selective or random cutting of trees for timber;
* modest grazing by cattle, sheep and horses;
* selective mowing, coppicing and other small-scale extraction activities;
* selective induction of sand blow-outs and other forms of erosion.

In many cases where exogenous influences are small, conservational use is best off with a *laissez faire* ecological management, particularly if the history of the use does not show dramatic impacts on ecological

patterns and processes. The above examples all lead to a certain upgrading of natural values. Other "minor" use forms like recreational use, defence against water and water-supply also profit from modest or little efforts for ecological management, as they share the interest in a proper functioning of the resource ecosystem.
Ecological management can thus often be sober, if resource use management cares for containment of the use forms. Only in case of badly damaged resource ecosystems (e.g. unacceptable extents of erosion) ecological management has to be intensified. But even then the "doing almost nothing" strategy may lead to quick recovery of parts of the ecosystem.

Effectiveness of management

Any management action will be judged for its effectiveness as related to costs. In case of marketable goods and services, benefits and costs can be compared in terms of money. Multiple use of natural resources often concerns non-marketable services (see Chapter 2) with semi- or intangible benefits. Yet we need measures for these benefits because otherwise management cost-effectiveness cannot be assessed properly.
As we have seen, a variety of aims and objectives may be formulated for multiple use of an area. If these are stated properly, i.e. denoting measurable use levels and denoting the period required for realizing the aim or objective, assessing management effectiveness would be fairly simple. However, most aims and objectives are often hard to express in quantitative terms. A problem emerging from this is the *interpretation* of what actually happens, in relation to aims and objectives. Do induced changes in multiple use really contribute to these or do they not?

Again there is a need for analysis here. However, it is not useful to try to generalize such situations in terms of procedures, as most real-world situations will differ from each other very much. In the second part of this book we shall analyze such problems for two case studies. In this chapter only some general issues are dealt with, concerning management effectiveness in the case of conflicting aims, integrated management-response relationships, external impacts of management actions and measures of effectiveness.

Conflicting aims and management effectiveness

As already noted above, the manager meets difficulties in the case of conflicting policy aims. Trees in conservational use cannot be cut for timber production, and recreationists should not pollute water-supply reservoirs. Any multi-objective solution for such problems would imply an only partial realization of most of the different aims.
A first option to solve such problems would be to translate a possible, policy-induced hierarchy of aims (major and subsidiary use forms) into

area use constraints. These could effectively be handled as management constraints. The resulting management policy would be to constrain certain subsidiary use forms (e.g. by "visitor management") to admissible user units per year, thereby giving room for the major use form. Depending on the successfulness of such management (which, however, might be very expensive), this option would be effective and relatively simple to realize. Use constraints should be derived from stimulus-response relationships and recovery rates as much as possible.
A second option would be to settle use conflicts by "experimental stewardship" as used in the U.S.A. (Floyd, 1988) for public lands used for grazing, timber production, recreation and conservation. Management decisions are to be taken as a result of consensus between user representatives (each of them having veto power). This procedure has led to a remarkable decrease in the number of cases needing litigation.
A third option would be the zoning of use forms. This may also be an area use constraint configuration, especially in small areas. In large areas the manager may deliberately choose to *develop* (e.g. by design) sites and parts of the area for particular use forms, stimulating a use form here while discouraging it there. The net balance of use intensities may then be constant. This option may be very expensive if development of sites would require much investment and labour.
A fourth option would be to rely on ecological management as an instrument to create more "room" for multiple use. By establishing a mosaic pattern of different habitats, most use forms could possibly be satisfied (e.g. by the function of "edges" for stationary recreational use). In the case of conservational use this option would only be acceptable if conservational use would aim at the *development* of particular habitats rather than at the preservation of existing ones.
In all cases one kind of information seems most important: the effectiveness of actions in terms of response in use forms and response in resource characteristics.

Integrated management-response relationships

In fig. 2.2 the actual use of a site within a multiple use area was assumed to be determined by a number of factors related to the visitors, to external (outside the area) conditions and to internal conditions. We may add now "management" as the whole of actions leading to deliberate changes in the external and the internal conditions (assuming that another set of changes is induced by the users). We may also suppose that, once we have got hold of cause-effect relationships in the chain "management → use → response of the resource", we may be able to govern use of the area within chosen limits under sustainability constraints. This type of relationships can be called **integrated management-response** (IMR) **relationships**.
Obviously, all concepts discussed before (use patterns, capacities, SR relationships, recovery, resource use management and ecological manage-

ment) should fit into IMR relationships. The format shown in fig. 3.17 (pag. 57) is an example for simple IMR relationships as regards recreational use. Adding several use forms to the "visitors" block creates a simple IMR relationships format for multiple use.
We necessarily encounter the same problems as discussed in Chapters 2 and 3. Actually there is almost no insight in IMR relationships, as research on these has seldom been done (were it only because ecological changes may take many years). Most management focuses either on use problems or on ecological impacts but seldom on both, let alone that these would be integrated. The same holds for many research efforts, e.g. as regards outdoor recreation and its ecological impacts (see e.g. Mercer, 1979; Van der Ploeg, 1987). Yet this approach is promising because at least one question can be answered: which are the ultimate impacts of a management action on chosen use and resource variables?
In complicated multiple use situations it may be very difficult to detect IMR relationships and to operationalize them. Even in these situations, however, a many-sided approach covering several use forms and also the resource ecosystem is preferent as it may minimize unnecessary use constraints or resource depletion.

A simple model for IMR relationships

We have extended the simple STELLA trampling model of Chapter 3 to an comparably simple simulation model for IMR relationships. In this IMR model the number of visitors is steered by the population size and by an increasing participation in recreation over time. We have chosen different initial values for the output variables, considering the fact that in 1960 (the first year of the simulation period) these variables were already influenced by visitor presence. We have also added "signals" to the manager (cf. fig. 3.17) and the manager's action is closing the site for the public during part of the tourist season, thereby effectuating some 50% reduction of the visitor intensity. Specifications of the model are given in Appendix B; figure 4.2 shows some model runs.
The pulses in the "50% regulation" runs are related to the recovery of the vegetation. Once the regulation has been enforced, vegetation recovers and surface bare ground decreases, thereby stopping the "signals" for regulation. In due course visitor pressure becomes so high that the regulation is permanently applied.
The results show the effectiveness of the reduction in visitor intensities. However, running the model for a much longer period (up to 100 years) indicates that the increasing population (if that presumption would hold) leads to a gradual decline of living vegetation and litter and to dominance of bare ground.
Such simple models have no explanatory value. Their value lies in the logical linking of variables that indicates how performance of variables can be judged to take management decisions.

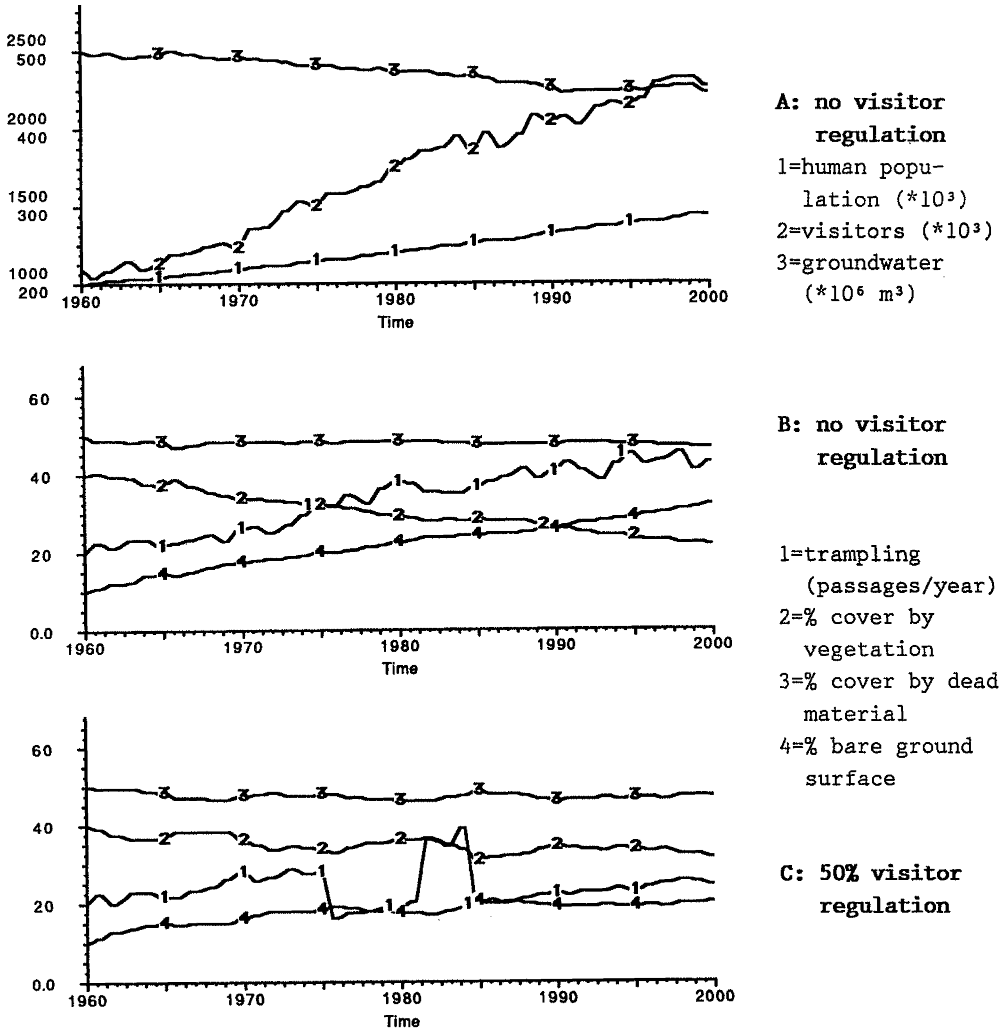

Figure 4.2. Simulation results from a simple IMR relationships model run for the period 1960-2000.

External impacts of management actions

Effectiveness of management actions is not only to be assessed as regards the area itself. Also impacts of management actions on the world outside the area, particularly on the region, have to be judged in relation to effectiveness. Some examples may clarify the importance of such impacts.

1. If *conservational use would be enhanced*, management actions might include restrictions on recreational use and also on use for water-supply. As regards recreation, people would partly go to other areas. Their expenditures (on consumption of food or beverages, on

lodging facilities, on renting bicycles, horses or boats, etc.) would then also go elsewhere at the cost of the profits for trades people in the vicinity of the area. Traffic patterns would also change. As regards water-supply, restrictions on the production might induce an increase of the water price for the region as a whole.

2. If *recreational use would be enhanced*, the reverse would be the case (except for water-supply). Conservational use forms in particular would get less room; people interested in wildlife would have to go elsewhere, if a "substitute" area would exist at all.

Such regional changes in resource use patterns may be important enough for complaints to the manager or to the governing body to stop the actions and sometimes to re-establish the original situation.

Measures of effectiveness

Impacts of management actions can be measured by comparing variables before and after the action. Focusing on outdoor recreation, examples of relevant variables are:

* number of user units at site i (to be specified according to action objectives);
* behavioural aspects of users (to be specified);
* space occupied by use (permanent or by intervals);
* "emissions" (pollution, noise) by use aspects;
* resource indicators of the site as defined by SR relationships between use forms and these indicators;
* qualities and quantities of management actions changing the original situation;
* expenditures and receipts related to actions.

Clearly it is not realistic to suppose that all these variables could be frequently monitored. Rather some of these have to be measured occasionally, sampling only parts of the area. For these selections some *a priori* knowledge is necessary, obtained from an initial survey and scientific knowledge about these variables as indicated in this chapter and the previous ones.

But even then the most difficult problem of all is to set criteria for variables in order to assess achievements. Basically this is a management decision in all cases where no criteria exist that are generally accepted. As we have seen, the market mechanism is often not reliable as regards prices for goods and services. For benefits from recreational or conservational use, for example, criteria are hard to set, particularly because there is no agreement about what is better than what. Yet this does not relieve the manager from the responsibility to formulate such criteria, because otherwise arbitrary management decisions would be the result.

5. INTERMEZZO:
"Back on our feet again"

"The first part of the book .... provides a basis for understanding the nature and the range of the problems involved", we wrote on page 8. After many pages on theory and possibilities, one may question to what degree we can understand the complex matter touched upon here. Unpredictable use forms, non-tangible benefits of use, uncertain cause-effect relationships, doubtful ecological resource indicators, contrasting policy aims and constraints on management, they all contribute to uncertainty about the effectiveness of management options. In order to summarize our findings, we shall introduce an adapted version of figure 1.1 where we attempted to indicate the core of this book.
We then move onwards to real-world situations which may supply useful information for a better understanding of "multiple use". This Intermezzo briefly introduces two areas in the Netherlands that are nominated or proposed as National Parks. For each of these areas we select a few management issues that pertain to our analysis. These issues shall be analyzed in the next chapters in view of the considerations in the previous chapters.

Incorporating the concepts

As we have seen in Chapter 2, multiple use includes use interactions (indifference, cooperation, competition or exclusion). Use patterns influence use interactions and *vice versa*. Information about use patterns is also important in tracing impacts on the resource ecosystem. Some patterns are very predictable, others (e.g. recreational use) only partly. This requires both a long-term and a short-term control by the manager. However, it is difficult to base actions on value judgments about multiple use, as several goods and services supplied by the resource yield intangible benefits.
Sensitivity (for particular types of use) and resistance (regeneration power) of the resource ecosystem determine carrying capacities of parts of the ecosystem for different use forms or an assembly of them (Chapter 3). Information is needed about stimulus (use)-response (ecosystem) relationships and about the recovery time after use. However, such information is certainly not equivocal, because different resource components react differently, as shown by examples for one kind of impact (trampling) from recreational use. The combination of impacts from various use forms also hinders interpretation of the information.

National and regional policy aims largely determine the manager's "decision space" (Chapter 4). Management, decisions and actions are constrained by conflicting policies, by ecological and social limitations, by budget limitations and by available knowledge. Actual instruments for multiple use and resource management include regulation of external conditions (outside the area), regulation of resource use (entrance regulations, zoning, information) and ecological management. Conflicting aims can be handled by using a hierarchy of aims, by striving for consensus between users, by applying zoning or by creating ecological differentiation. The effectiveness of management is hard to assess, partly because many benefits are intangible. Nonetheless use intensity, user behaviour, ecological indicators and precise information about management actions themselves may be helpful tools. Integrated management-response relationships can help to bring together information about management actions,

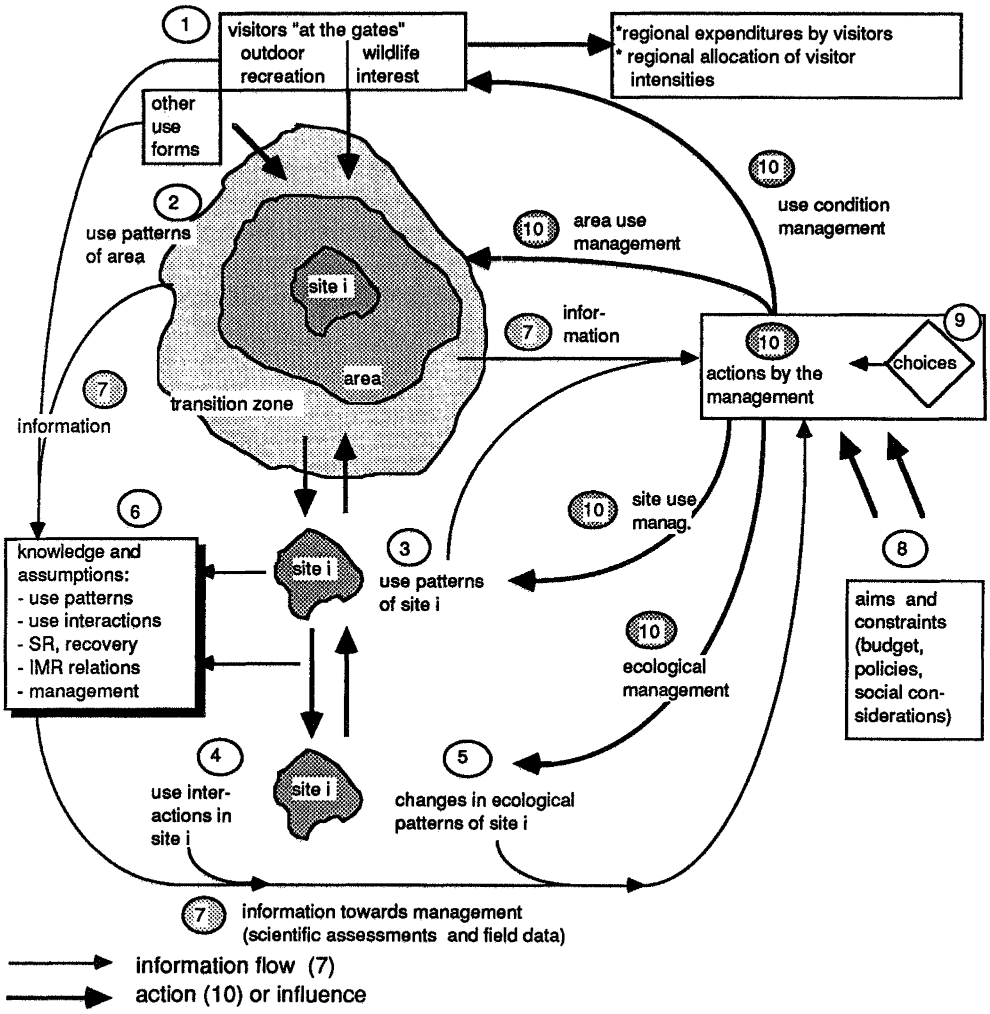

Figure 5.1. Relationships between use patterns, ecological patterns and actions, as regards recreational use.

use patterns and resource responses within a consistent framework. However, criteria for effectiveness remain hard to define.
The role of the "body of knowledge" is thus emphasized in this book. Without substantial (and integrated) knowledge, management actions would be taken mainly because of the pressure from aims and constraints and a hardly interpreted stream of information from within the area.

Analogous to fig. 1.1 (page 7) and also based on fig. 2.2 (page 22), the conceptual model for recreational use shown in figure 5.1 illustrates how management actions can be placed in a general context of area use by visitors. Management needs information (7) about the number of visitors "at the gates" and about other use forms (1), how they use the area (2), how they specifically use site i (3), how use forms interact at site i (4) and how the ecology of site i changes (5). All management actions (10) are based on choices (8) resulting from complex and often imperfect judgments related to this information. These judgments may be helped by knowledge and assumptions about various aspects fed by research on these (6). Finally, management actions are related to aims and constraints (9), and some actions may influence regional allocation of use intensities and regional expenditures by visitors (1).
Fig. 5.1 provides a framework to analyse multiple use management situations for areas in general. We shall perform this analysis for specific issues in two areas. These areas are introduced below with emphasis on ecological, multiple use and general management characteristics.

The North Holland Dune Reserve

Dunes stretch along major parts of the north-western coast of the Netherlands. They are part of an extensive dune system from the north of France to the north of Denmark. Figure 5.2 (next page) shows the location of the North Holland Dune Reserve (NHDR) and the approximate boundary for the proposed National Park.
The proposed National Park in this region is to consist of the NHDR, the dune area north of Egmond ("Duinen van Six") and the dune area west of Schoorl ("Boswachterij Schoorl") (Anon., 1981). The ownership status of these three parts is different. The NHDR is owned by the province of North-Holland and is managed by PWN, the regional public body that runs the water-supply for large parts of the province. The part north of Egmond is privately owned and managed; the part west of Schoorl is owned by the State and is managed by the State Forestry Service. The shoreline is owned by the State and is managed (for sea defence) by the Ministry of Transport and Waterworks. The total surface area of the National Park falls under the jurisdiction of five local authorities and sixteen local "zoning plans" (see page 65). It also comes under the competence of two regional plans. Finally, in three national land use plans ("Structuur-schema's", page 64) this proposed NP plays a role.

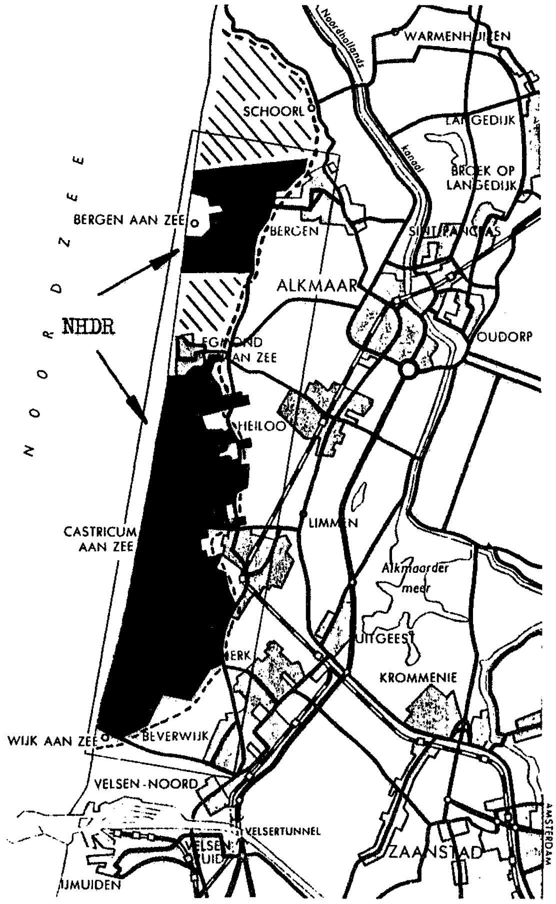

Figure 5.2. Location of the proposed National Park and the NHDR.

Landscape and ecology

Geomorphologically, the dunes of North-Holland are relatively young, i.e. the age is between 1000 and 200 years. North and south of Egmond (see fig. 5.2) the soil types are completely different: in the south, calcareous, nutrient-rich dunes; in the north, acid, nutrient-poor dunes with low chalk content.
Another difference in geomorphology is formed by the change along the coast from the beach to the inland dune edge. In the "young", outward parts (i.e. adjacent to the sea) dune ridges and valleys have been formed, while the inland parts, the older dune systems, are often less accidented. The outward dune habitat is very open, with a dominant vegetation of grasses and herbs, and locally shrubs, while the inland habitat is often dune woodland.
The vegetations of these major parts differ considerably. Doing (1974) has made a distinction between so-called "landscape types" that may be regarded different habitats. Calcareous soils are characterized by habi-

tats where *Ammophila arenaria*, Rubus caesius and Hippophaë rhamnoides* are representative species, while acid soils are represented by *Koeleria cristata and Corynephorus canescens*.

Aspects of multiple use

The whole area has been deeply influenced by human activities, mainly land use for cropping (e.g. potatoes) and for sheep grazing. Sites adjacent to villages (Wijk, Egmond, Bergen) have been intensively used for drying laundry and nets of fishermen. Other activities were gathering wood for fuel and trapping rabbits. All these activities together have sometimes led to erosion but have also caused a great variety of different habitats. This variety is reflected in the large number of plant and animal species found in the area.
The manager of the NHDR, in accordance with the provincial authorities, has recently restated the principal aims for using the area (Anon., 1985). Sea defence, water-supply, nature conservation and outdoor recreation are most important; nature conservation is taken as the starting-point. "Given certain constraints, conservation of natural values as a principle is a decisive touch-stone for management actions. Important constraints are:
- from use for sea defence: maintenance of the shoreline and complying with the prescriptions of the dune regulation;
- from use for water-supply: the use of most of the area for water-supply activities, the influence on the water balance and the transport related to these activities;
- from use for recreation: creation and maintenance of facilities for various recreational activities." (Anon., 1985, p.16).

For the NP as a whole, several existing use forms may be added. In the northern part (managed by the Forestry Service), timber production (or at least maintenance of the standing crop) is important. In the privately owned part between Egmond and Bergen, sites are still used for small-scaled cropping of vegetables. In the NHDR, timber production is not an explicit management objective but parts of the woodland (particularly those planted with pines) are used as such. In view of the aims for NP's in the Netherlands (see Chapters 1 and 4), these "productive" use forms are to be excluded in due time. Recent trends in forestry in the dunes (e.g. Anon., 1989b) indicate a shift from production objectives towards conservational objectives.

Apart from some exceptions, overnighting and residential building is not allowed in the whole of the NP; these use forms are confined to the villages. Some of the existing campings, however, are actually used for residential purposes in the summer season. The far majority of the people staying there comes from the big cities of Amsterdam and Zaanstad.

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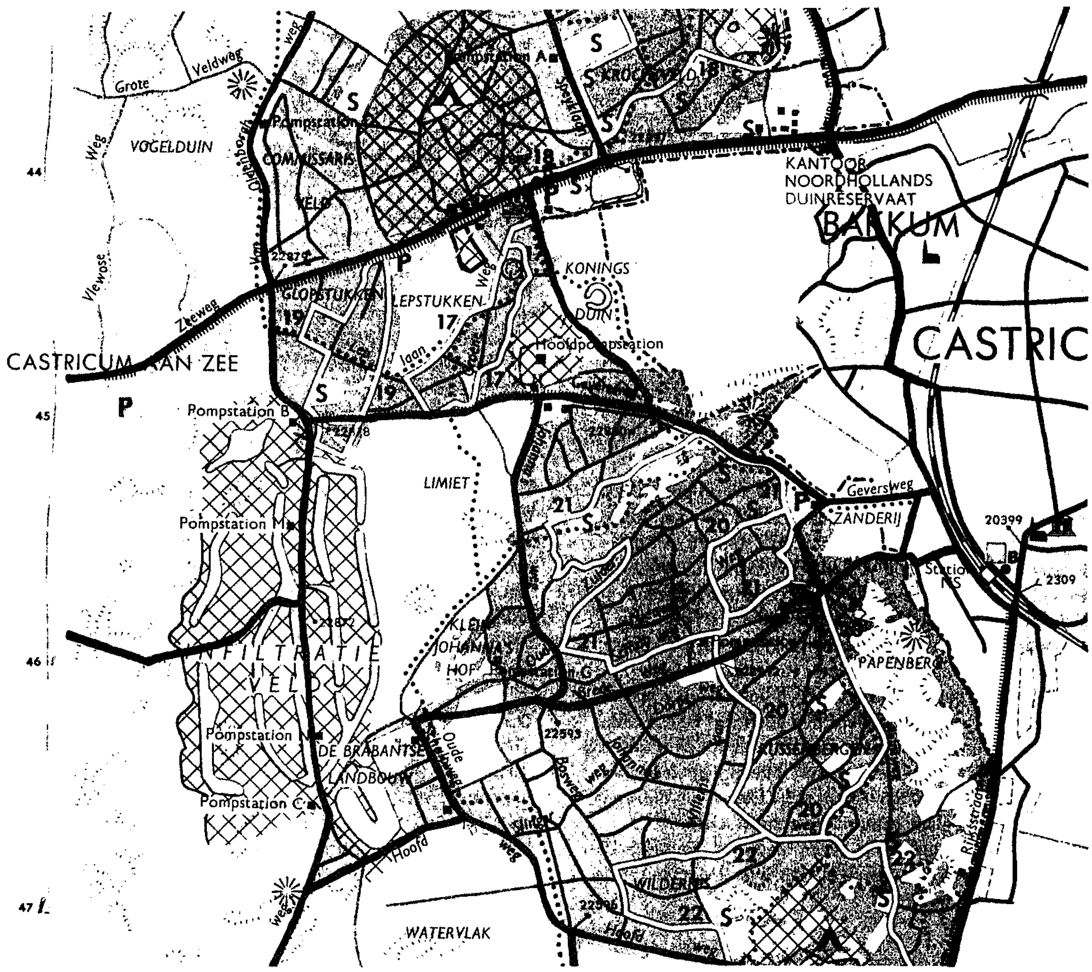
* Appendix A contains a complete list of English and scientific names.

Hunting for recreational purposes is only allowed in the area between Egmond and Bergen (private ownership). In August, picking of dewberries is allowed in the NHDR. During that period visitors are not restricted to roads and paths.
Generally, cars are not allowed in the NP area, apart from management vehicles. In the NHDR, scientists and also some elderly persons may obtain dispensation for certain sites during specific periods. Cyclists are allowed throughout the area and this forms an important part of the recreational use. For horse-riding, marked trails have been designed.
The majority of the visitors to the NHDR lives in the region (i.e. the province of North-Holland). People from the adjacent towns and villages visit the Reserve most frequently, but they are outnumbered by visitors from the big cities and towns. According to Anon. (1986), most visitors mainly come for a walk or for cycling (80-90%). Minorities are mainly interested in stationary recreation (sunbathing, playing; 20%) and sports (jogging, race-cycling; 10-20%) or horse-riding (3%).
As regards conservational use, many sites are refuges for rare plant and animal species, particularly in the NHDR. Dune areas in the Netherlands are generally appreciated by the public for their aesthetic values. The NHDR encourages much scientific research in various disciplines, biology, hydrology and physical geography being the most important ones. The proposed NP has two visitor centres (Castricum and Schoorl) that inform the public about the area and also serve a broader "environmental education" purpose. Guided tours are organized by the different managers.

Management

Particularly in the NHDR, partial segregation of use activities by zoning is very characteristic for the management. Figure 5.3 (next page) gives an example for part of the reserve. Campings and water infiltration areas are not accessible to recreationists or users other than the people "who belong there". Within the infiltration area, only two roads have free access. Along the major road to Castricum aan Zee, the visitor centre, a restaurant, a small sea resort (shops, cafetarias) and an extensive parking place (parking ticket compulsory) are located. Only few paths lead through the outward dunes; in the dune woodland (dark colour) an extensive path network, including guided walks, provides many opportunities for pedestrians and cyclists. Visitors have to keep to the paths generally (apart from the dewberry picking period in August, see above), but a large number of playgrounds (denoted on the map with "S") are provided. Some dunes have lookout facilities (*).
In the other areas belonging to the proposed National Park, the management is largely comparable, be it that in the Schoorl area there is no restriction for visitors to keep to the path. In all parts, special sites have been fenced off in view of conservation of natural values, notably rare habitats and sites that are important for breeding birds.
Parking lots are provided along the whole of the NP area. Most of these

are relatively small (20-100 places). Additional parking space is found in the villages and near the beach. Facilities like restaurants and cafes are almost exclusively located at area boundaries, often next to important roads. Within the area, tourist facilities are very simple: benches, litter bins, lookouts and some playgrounds.



1 km
not accessible to the public (except roads)
P = parking lot
S = playground
= lookout
= paved road
= camping area
•••• = horse trail
17 = guided walk
= other footpath

Figure 5.3. Use zoning in a part of the North Holland Dune Reserve (adapted from the tourist map for the NHDR).

The "Biesbosch" National Park

The Netherlands can be considered part of the delta of the rivers Rhine and Meuse. At the east side of this delta, the Biesbosch area has been a freshwater tidal area since the 15th century. The geographical location of this area is shown in figure 5.4.

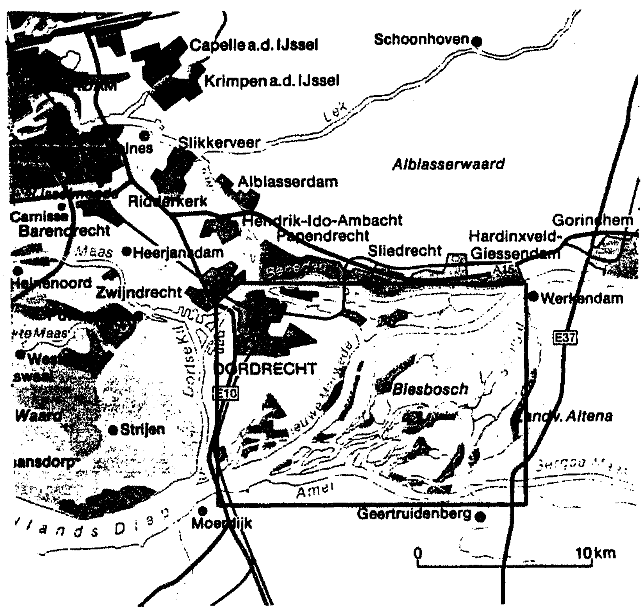


Figure 5.4.
Location of the Biesbosch National Park

As a consequence of the catastrophic floods in 1953 that inundated large parts of the estuary west of the Biesbosch, most of this estuary has been secured against the sea by dams. The construction of the dams in the Haringvliet in 1970 ended the tidal movement in the Biesbosch area. This has led to drastic changes in both the ecology and the use of the area.
The surface area of the denominated National Park is approx. 7,000 ha. Most of the area (80%) is owned by the government (State Forestry Service and Dept. of the Treasurer). Considerable parts (18%) are owned by corporate bodies for outdoor recreation and for water-supply; small parts are privately owned. The management situation is largely comparable to this ownership (some areas being on rent for agricultural purposes). The total surface area of the National Park falls under the jurisdiction of the Government, two provinces, five local authorities, two provincial planning schemes, eight local zoning plans, two polder boards and two outdoor recreation boards. It also comes under five national land use plans. For the denominated NP a Council has been established, including all participants with public and private rights and tasks.

Landscape and ecology

After the St. Elisabeth flood of 1421, most of the former polders in the region vanished. Sedimentation of particles and sand accretion, transported by rivers and by the tidal movement, created new land where pioneer vegetation with bulrush ("Biesbosch" means "wood of bulrush") settled. Soon large parts were reclaimed again for agricultural purposes. Outside the dikes many areas vegetated with bulrush and reed (mudflats) or willows (on the higher parts; holms) were embanked to be used for exploitation of the vegetation, for duck decoys etc.
After 1850 much more land has been reclaimed and two new water connections have been dug. This has fastened land accretion. Closing the Haringvliet in 1970 has reduced the tidal movement from c. 1.8 m to 0.2-0.7 m. This has led to erosion and crumbling away of the land, creating a marsh habitat.
At present the NP area is dominated by open water, reed vegetations, wet and dry scrubland, willow woodland (partly coppiced), grasslands and river dunes with poor grassland. Some of these vegetation types are very species-rich. The holms and reedlands that are not in use anymore have become wilderness areas with abundant growth of *Urtica dioica*, *Chamerion angustifolium* and *Angelica archangelica*. The area as a whole is developing towards alluvial woodland. A general picture of the distribution of vegetation types and land use is shown in figure 5.5.

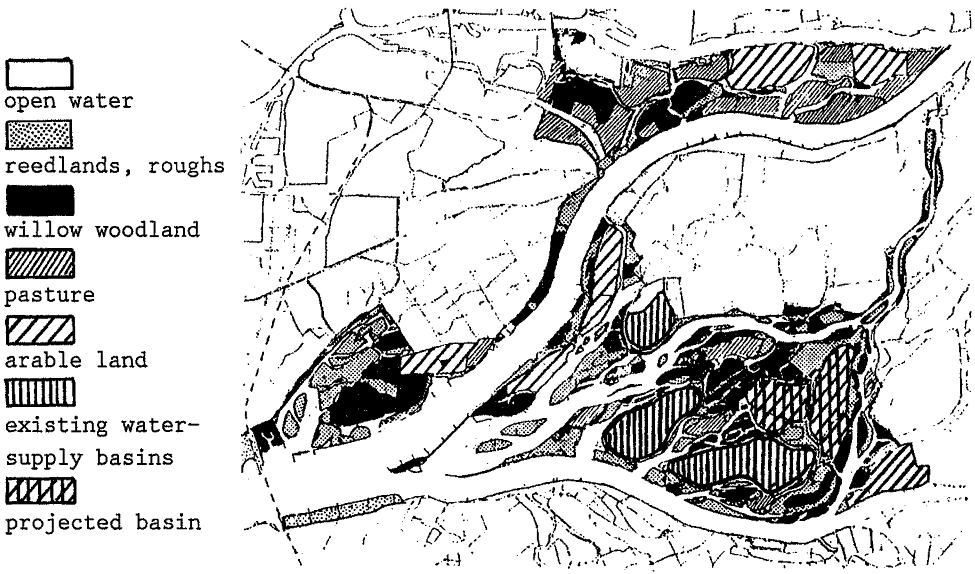


Figure 5.5. Vegetation types and land use in the Biesbosch area.

The area is very important for migrating and overwintering birds (ducks, geese, birds of prey). In recent years 123 bird species have bred in the Biesbosch, among which very rare species like Night Heron and Kingfisher.

Aspects of multiple use

From ancient times on, the NP area has been used in a variety of ways, most of them in relation to the wetland character of the area. For convenience, we shall group particular use forms and neglect some less important ones.

At present, *outdoor recreation* is the most important use form in the Biesbosch area. After 1970, most streams and creeks have become much more accessible because of the absence of tidal movements. Most of the recreation is water-based; the far majority of the boats is motorized. From various places cruises are organized. As the wildlife interest and the visual amenity of the area are considerable, many visitors (28%) claim to come for these features in particular (Van der Linden & Van Eijk, 1984). The area is very crowded on spring holidays (Pentecost) and in the summer season (5,000-6,000 boats per day). Angling is one of the important recreational activities.

Conservational use is to be the dominant use form of the denominated NP. Being one of the largest wetlands in the Netherlands, some 1,500 ha have been established as nature reserves already. The Biesbosch is seen as a "stepping stone" in a series of wetlands; the whole of such a series would enable extinct species to colonize the Netherlands again.

Water-supply, mainly to the city of Rotterdam is ensured by three large basins sited in the heart of the Biesbosch. Their total surface area is approx. 700 ha. A fourth basin has been planned but has not been constructed yet.

Water management for various purposes plays an important role in the area. Although there is almost no tide anymore, dike height has to be 4.30 m in order to prevent flooding during storms. Also the increased water displacement by large ships and their speed require fortification of embankments.

Use of the area for *infrastructure* includes some major courses for ships through and along the denominated NP. Major roads board the area; inside, only secondary roads exist. Energy infrastructure takes the form of pipeline trajectories (only indicated) and high-voltage power lines.

As intensive *agricultural use* is not compatible with NP aims, areas with such land use do not form part of the NP although they are located at the edges. Extensive grazing lands, including important conservational use, are included in the NP.

Exploitation of biotic resources has strongly declined after 1945. However, willow coppicing and reed cutting are still done. Duck decoys and hunting provide modest amounts of poultry.

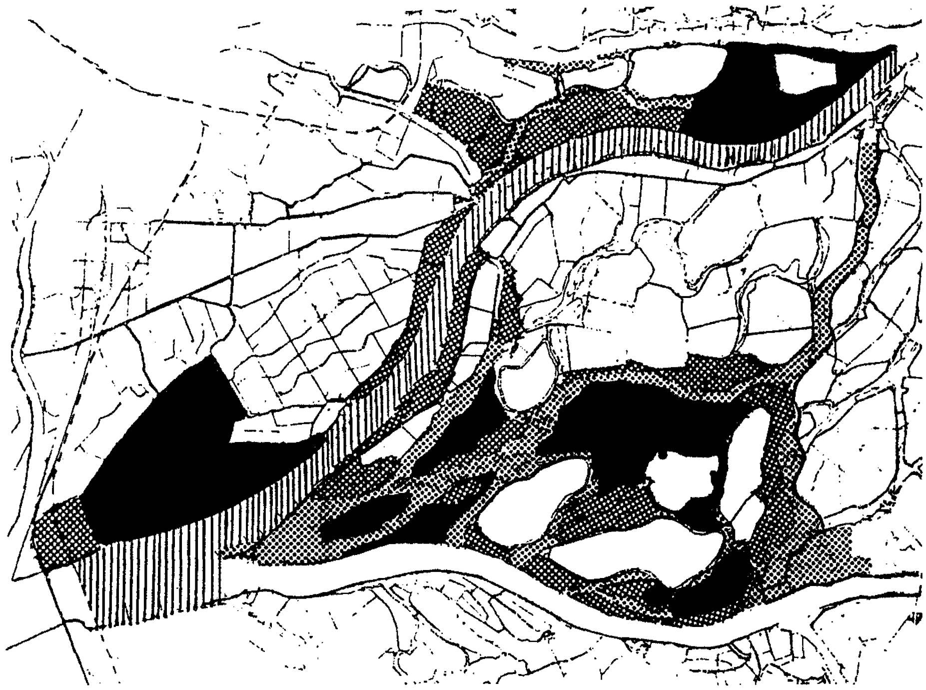
"Urbanized" use (residential use and industry settlements) is confined to the edges of the NP. In some places house-boats are abundant.

Incidently, the area is used for *military training* purposes. The use of helicopters is a reported nuisance to other users of the area.

As regards *information*, recently two visitor centres have been established; also a Biesbosch museum has been created, where old crafts from the area are demonstrated. Several nature trails introduce the visitors to all aspects of the area, and volunteers are guiding groups (mainly from cruises) through interesting sites.

Management

As in the example of the dunes, zoning of different activities is also characteristic for the Biesbosch area. The water-supply basins, the duck decoys and the agricultural areas are not accessible to other users. The existing nature reserves are only accessible for scientific research and for guided excursions. To a large extent use forms are thus spatially segregated.
Recreational use is also subject to zonation. Parts of the waterways are only open to non-motorized boats; in most parts of the area, landing by



nature reserves (almost no access)

nature reserves with important limitations to recreation

natural areas with recreation

areas with other main use forms

Figure 5.6. Zonation in the Biesbosch area, as proposed by the Committee for National Parks (Anon., 1985a).

any boat type is not allowed at all; throughout the whole area boats must not stay longer than three days at the same place. Some sites are closed for the public during the bird breeding season. On the other hand, no entrance fee for entering the area is required.
In an advisory report of the Committee for the National Parks (Anon., 1985a), sailing regulations have been proposed to be tightened up. Figure 5.6 shows a general outline of the proposal. Nature reserves (with almost no access for visitors or with limitations on mooring and anchoring) are proposed to occupy most of the NP surface area. Only a modest part of the NP would be available for all present recreational use forms.
Another important form of zonation of recreational use is intended by the creation of so-called "sieves". These facilities are expected to "catch" different types of visitors selectively, thereby "letting through" a lower number of visitors. Macrosieves (more than 100 landing places) are located at the edge of the NP area and have good facilities; mesosieves are located in "strategic" sites within the area, they can harbour 20 to 100 boats, and they provide simple facilities like playgrounds and look-outs; microsieves can accomodate 10 - 20 boats and provide almost no facilities.

Use interactions in the case study areas

From the descriptions given above, five use forms emerge as important ones in the scope of this book: "intensive" recreation (high densities of recreationists, noise etc.), "extensive" recreation (low densities, quiet, wildlife interest etc.), nature conservation, water-supply and sea defence (NHDR only).
Table 5.1 shows a first and partly intuitive qualification of the interactions between these use forms. It is intuitive because only generalized

Table 5.1. Use forms and interaction types.

IMPACT on: / USE FORMS:	intensive recreation	extensive recreation	nature conservation	water-supply	sea defence
intensive recreation:	x	-/E	-	-	-
extensive recreation:	0	x	0/-	0	0/-
nature conservation:	+/-	+/0	x	+	+
water-supply:	0/E	-/E	-	x	0
sea defence:	-/E	0/E	-	0	x

0 = indifference; - = competition; + = cooperation; E = exclusion

and expected interaction types are mentioned; actual multiple use situations may show very different interactions. The interaction types are characterized according to the classification given in Chapter 2. Information about possible interactions in dune and wetland areas has been taken from Anon. (1976), Boorman (1977), Bakker *et al.* (1979) and Anon. (1982).
Table 5.1 suggests that conservational use is being competed by almost any other use form. Water-supply and sea defence are only in competition with (intensive) recreation, if they are not protected by (partial) excluding measures (lower left part of table).

The multiple use and the general management characteristics of both the North Holland Dune Reserve and the denominated National Park "De Biesbosch" suggest that past and present zonation of activities are predominant factors in explaining actual use and ecological *status quo* of the area. Past zonation includes decisions about the location of water reservoirs, agricultural use and location-bound activities like sea defence, but also parts of the infrastructure. Present zonation is largely restricted by past zonation and is being enhanced by management.

Which knowledge required?

From the descriptions of the two areas and the "intuitive qualification" of interactions we cannot yet assess the desirability of the present multiple use configuration or the stability of it. Thus we do not yet know whether the present situation (including the present management) means sustainable multiple use or not. Neither can we assess whether the present management is "to the point" (i.e. pertaining to aims and objectives stated) or not. We do not yet know whether the management should be intensified (in favour of one of the use forms) or should be extensified (because of equal effectiveness at lower costs).
Even if a comprehensive understanding of all use patterns and resource responses would be useful, this would take very substantial long-term research efforts. In reality, only bits and pieces of multiple use patterns and processes have been studied, and even the knowledge about the five mentioned use forms is far from comprehensive. Yet we select a number of cases about multiple use issues, in order to work towards an understanding of "multiple use" in a more general sense.

Selection of specific management issues

Considering the five use forms emphasized in the previous Sections, and also the present situations in the two study areas, three main - actual or potential - management themes emerge:

1) managing nature conservation as regards its interactions with the other use forms, with particular reference to recent changes in conservation aims;

2) managing (autonomous) increase of, or changes in recreational use patterns of the areas (both intensive and extensive forms), as regards interactions with nature conservation, water-supply and sea defence;
3) managing changes in water-supply activities as regards interactions with the other use forms, including both protection of water-supply sites and expansion of these sites.

For each of these three main themes, specific issues have been selected both for their relevance and as regards the availability of research data. For the NHDR and the Biesbosch, the issues chosen are as follows.

North Holland Dune Reserve

Changes in conservational use:
* Zoning as an instrument in restricting other use forms, particularly recreation and water-supply.

Changes in recreational use:
* Perception of changes in recreational use by the visitors themselves.
* Horse-riding as an activity with a limited but very severe impact on the other use forms.
* Berry picking as an activity with a widespread but mostly extensive impact on conservational use, on use for water-supply and on use for sea defence.

Changes in water-supply:
* Changes in groundwater levels, influencing other use forms.
* Changes in water extraction as regards the area used for it and the impacts on recreational and conservational use.

Biesbosch National Park

Changes in conservational use:
* Zoning as a tool in restricting other use forms, particularly recreation (motorized boats, mooring and anchoring prohibitions).

Changes in recreational use:
* Perception of changes in recreational use by the visitors themselves.
* Tourist spots as an example of the impacts of tourism on conservational use.
* Impacts on breeding bird populations as an example of possible differences between extensive and intensive recreational use.

Changes in water-supply:
* Changes in time (including future options) of water-supply area demand, related to recreational and conservational use.

6. THE CASE OF THE NORTH HOLLAND DUNE RESERVE

This chapter aims to illustrate some of the multiple use issues analyzed in the previous chapters. The interactions in the North Holland Dune Reserve (NHDR) between recreational use, conservational use and water-supply form the major part.
Most of the management issues selected (zoning for nature conservation, perception of recreational changes, horse-riding, dewberry picking, water-supply) do not cover acute problems. As will be shown, research data on use patterns, perception, stimulus-response relationships and recovery do not reveal the need for drastic changes in management action. Nonetheless, several management options are considered for their impacts and their effectiveness, as regards present and future situations. Finally, future actions, constraints (partly in relation to a possible National Park status) and important gaps in the available knowledge are discussed.

Introduction

Considering the information about the North Holland Dune Reserve given in Chapter 5, no acute multiple use problems seem to emerge. The management has fair control over most use forms involved. We must realize, however, that this situation is the product of a long term consistent management regime. Users have grown accustomed to gradual changes in the management during the past forty years. Moreover, the NHDR area has never been used for one specific purpose exclusively. Outdoor recreation intensity has always been low (expressed as number of visitors per hectare per year) compared to well-known and popular dune areas like Meijendel or the Kennemer Duinen National Park. Yet the present multiple use configuration may be unbalanced in terms of competition between use forms.

Multiple use problems in other dune areas

The selection of a dune area for illustrating problems in multiple use management is a deliberate one. As indicated in Chapter 2 (page 10), dune areas have been used for ages in a variety of ways. This multiple use has created problems in the past (e.g. overgrazing by sheep, followed by erosion of the sea defence dunes) and in the present. Almost in all countries with dunes these problems occur, e.g. Scotland (Mather & Ritchie, 1977), England (Boorman, 1977), Ireland (Carter, 1975), France (Van Ommering, 1985), Denmark (Houston, 1983) and Poland (Piotrowska, 1979, 1988). Some examples in the Netherlands are given below.

Outdoor recreation
Heavy pressure on the dunes, mainly by pedestrian visitors, has notably been reported from Meijendel (Anon., 1978), Berkheide (Anon., 1978a) and the Wadden Islands (Anon., 1977). The main problem is caused by people walking randomly through the dunes in great numbers, creating paths, erosion spots and gullies, destroying vegetation and disturbing animals. On the Wadden Islands, an increase in illegal paths of 15-60 % within a period of six years has been reported. Horse-riding is also known to cause local physical damage to soils and vegetation. Tourist facilities (hotels, catering, parking lots, roads) are mainly concentrated in or near coastal towns and villages where they have replaced the original dune landscape; large numbers of visitors cause local erosion and damage to vegetations. A number of campings is situated within the dune landscape (De Knegt, 1979); apart from their area demand, little is known about their impacts on the dune resource ecosystem (Van Breevoort, 1978), other than the impacts already mentioned.

Water-supply
An increasing demand for drinking water over the last 125 years has resulted into a drastic lowering of the groundwater table (Bakker *et al.*, 1979). This has induced a remarkable change in the vegetation in many areas, wet dune slack vegetation being replaced by bushes and a flora less specific for the dunes. Extension of the water infiltration sites (e.g. in Berkheide, Anon., 1978a) has destroyed the existing ecosystems and has also considerably changed the vegetation by eutrophication (Van Dijk, 1984). On the Wadden Islands, the groundwater extracted in summer largely exceeds natural accretion of the volume. As many infiltration sites are closed for the public, water-supply activities also influence the pattern of outdoor recreation locally.

Forestry
In the dune areas managed by the State Forestry Service, plantations of Austrian pine are still managed for timber production, although the profits are low or even negative. These plantations are not suited at all for any nature conservation (Anon., 1981a). They partly provide opportunities for stationary recreation but are not attractive for wildlife recreationists.

Sea defence
In some areas (Texel; parts of the coast of North-Holland; Schouwen, Walcheren) the outward dune ridge is heavily managed because of high erosion risks by storms and also locally by intensive use by recreationists. Consecutive sand-drifts partly fill up dune slacks.

These examples show that serious problems in terms of competition of use forms do exist. Often these problems are "solved" by means of local or total exclusion of all but one or two use forms. In the NHDR, however, almost no substantial use forms have been totally excluded so far. The case of the NHDR thus seems appropriate to analyze situations where use forms do not (yet) exclude each other. In such situations, the manager needs to define constraints to changes in the overall use patterns, and to monitor such changes. As the NHDR may form part of a National Park in due time, aims and constraints for NP's (see Chapter 4) can be used to assess the NP possibilities of the present situation.

Outline of this chapter

We shall give some examples of interactions of various use forms, mainly by trying to assess the impacts of (past or future) changes in one particular use form on other use forms. As regards nature conservation, zoning measures are analysed; as regards recreational use, we have selected visitor perception, horse-riding and dewberry picking; as to water-supply, area demand and groundwater level are discussed. These examples will be dealt with as follows. Firstly, the issue is defined and some background details are given. Then the issue is analyzed using available data and the concepts discussed in the previous Chapters. This chapter concludes with an evaluation of the multiple use issues. As regards the statistical methods applied, in most cases non-parametric tests have been applied because the data do not fulfil the requirements for parametric tests (notably normality). For significancies, a critical level of α = 0.05 (one-tailed testing) has been used.
The majority of the information given draws on original research (mainly field work) done in 1973-1980 and in 1986. Many interim reports on this matter have been prepared (mostly in Dutch language), Van der Ploeg *et al.* (1978) and Van der Linden & Van der Ploeg (1982) being the more important ones. Results from other research will also be cited frequently, in order to provide information as completely as possible. It must be borne in mind, however, that most research cited (including the own efforts) has not been directed towards the multiple use issue.

Acknowledgements

Most of the research referred to has been carried out with the intensive help of students of the Free University. In particular I owe very much to Aart Vermeulen, Frans Vera, Kees Schotten, Hans ten Cate, Hans Rhebergen, Tonnie Rozijn and Herman de Jong. Thanks also to my colleagues Joop van der Linden, Lida Goede and Jean-Paul Hettelingh for their research efforts. Research permits, assistance and cooperation from PWN, notably messrs Veenendaal, Spaarkogel, Snater, Veering, Van der Vegte and Slings are also acknowledged.

Zoning for nature conservation

Nature conservation is a prime goal in the NHDR, under constraints from waterworks, sea defence and outdoor recreation (Chapter 5). The basic philosophy has always been to segregate these use forms from others only where necessary. However, nature conservation as one of the main objectives in the NHDR management almost cannot be separated from other use forms at all. Nature conservation pertains to the whole area as such and national objectives for nature conservation in coastal dunes also hold for the NHDR (Anon., 1981). This complies with the aims set for National Parks in the Netherlands (Chapter 4). However, the above constraints may impinge on these conservation objectives.

The issue

Having stated that the whole of the NHDR should be used for nature conservation, two questions arise:

1) what kind of nature conservation is meant?
2) how can this goal be achieved in a multiple use situation?

The first question cannot be answered unambiguously, but the following options can be deduced from national policy documents (Anon., 1981; Anon., 1989a):

* to enhance ecosystems that would be naturally present in the dunes;
* to protect plant and animal species that are characteristic for dune ecosystems, with emphasis on rare species;
* to maintain a variety of dune ecosystems (ecotopes, landscapes) according to the abiotic conditions (climate, soil);
* to exclude as much as possible *dominant* cultural (non-natural) influences;
* to enhance human(-induced) activities and management actions that serve the above options.

The second question possibly excludes an integral realization of the above options. So it remains to be seen to which extent these options can be realized without seriously inhibiting the other use forms.

As regards *sea defence*, there is almost no viable option for multiple use. The Dutch cannot afford a dune system that might at one time partly erode as happens in e.g. Britain (Mather & Ritchie, 1977) and Ireland (Carter, 1975). Such erosion has sometimes created gullies of some twenty metres deep and 0.5-1 km wide. In the Netherlands this would cause inundation of a large part of the hinterland; thus intensive management is needed. However, the fact that the coastline of North-Holland is partly receding is sometimes used as an argument to include several inward dune ridges into the sea defence system. The necessity of this extension has not been proved yet, and conservational use for the dunes pleas against it. Thus in the case of the NHDR the constraints of shoreline maintenance and the national dune regulation exclude any other

use except sea defence for the shoreline itself, at the cost of conservation goals for yellow (outward) dunes. However, the shoreline acts as a barrier for recreationists trying to enter the dunes (by means of formal prohibitions to enter and by barb-wire), thus improving conditions for other use forms in the rest of the NHDR. This zoning is not fully effective but at least reduces recreational impacts considerably, in comparison to foreign situations (notably the UK; Carter, 1975; Pizzey, 1975).
Yet the dune complex between Heemskerk and Castricum is some four kilometres wide and, as regards safety for the hinterland, there would probably be no objection against a break in the outward ridge. Such a break would create a tidal wetland ("slufter") between the first (outward) and the second dune ridge that would be very interesting from a conservational point of view (in accordance with recent national trends in development of natural values; Anon., 1988; Anon., 1989a), be it that the water-supply function of that part of the dunes would get into problems.

As regards the combination of conservational and *recreational* use, several options are discussed below. The combination of conservational and *water-supply* use is discussed later in this chapter (page 130).

Recreational use and its impacts on soils and vegetation

Zoning recreational use means to get the majority of the people only at places where you want them. From the nature conservation point of view, "nowhere except on paths and roads" (and just beside them) would be optimal. This cannot be achieved in reality but measures can be taken at three spatial levels: the area level, the site level and the "spot" level. Our research has focused on both the site and the spot level but some generalizations towards the area level can also be made.

Zoning is only necessary if *impacts*, e.g. trampled vegetation, erosion or disturbance of breeding birds are recorded or expected. In Chapter 3, several examples of such impacts have been given in terms of SR relationships. If the recorded response (of soils, vegetation or animals) clearly differs from desired levels, action may be taken.
In the case of the NHDR, dune slope erosion (where not deliberately wanted) has always been a prime reason for concern. After a period of relatively "passive" (i.e. not stimulus-directed) management by covering slopes with tree branches and dead seabuckthorn or by planting marram, the manager decided to apply barbed wire around eroding slopes in 1976. The opinions about the *cause* of this erosion markedly differed: recreationists (said the manager), rabbits (said some wardens) or simply natural processes (said some scientists). The erosion and similar signals of dune ecosystem degradation were only documented by personal, incidental observations; no SR relationships were assessed at the time. We may thus consider this to be "risk-averting" management.

Recreational use patterns
The recreational use of the NHDR does not show a homogeneous pattern. We have recorded use patterns in five sites, each with a size of one km². Figure 6.1 shows the location of these sites.

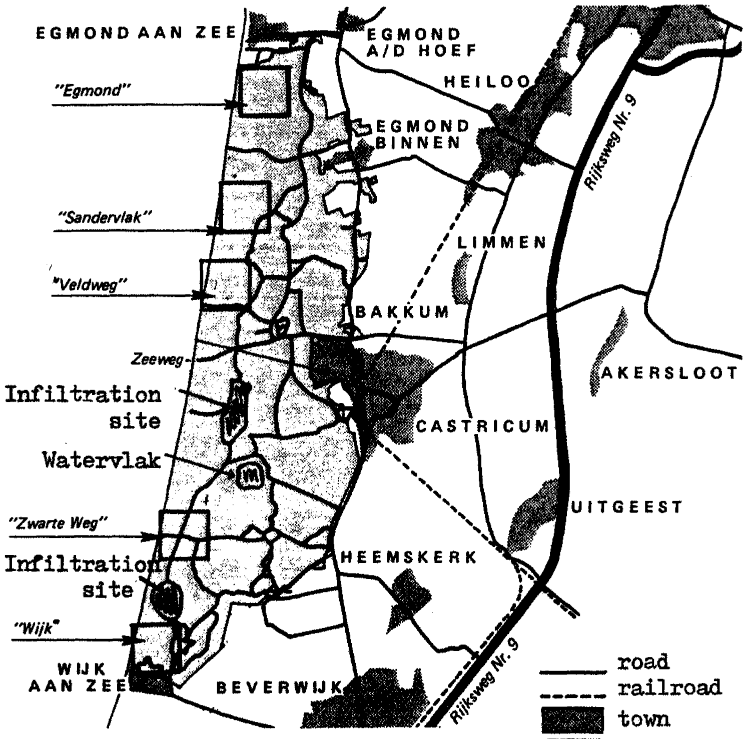


Figure 6.1. Research sites in the NHDR.

Two of these sites, "Wijk" and "Egmond", are adjacent to coastal villages and are frequently used by their residents (both inhabitants and tourists). Two sites contain important transit roads to the beach: "Zwarte Weg" mainly by cyclists, "Veldweg" mainly by residents of the camping Bakkum. The fifth site, "Sandervlak", is remote from villages and does not contain important throughroads.
Visitors were counted and indicated on maps in each of these sites by observers walking a fixed circular trail covering most of the site. These censuses were done in 1977, three times at each day of one week in the five months May to September. In addition, stationary observations of parts of all sites were done on all Wednesdays and Sundays of the weeks in which the mobile observations took place (Van der Ploeg *et al.*, 1978; Van der Linden & Van der Ploeg, 1982).
Recreational use patterns of the sites are shown in figure 6.2. Wijk and Egmond attract most promenaders, and the mentioned transit functions of Zwarte Weg and Veldweg are obvious. Sandervlak appears to be the most quiet site. A number of playgrounds are present in Wijk and Egmond; these account for 38% (Wijk) and 12% (Egmond) of the pedestrians.

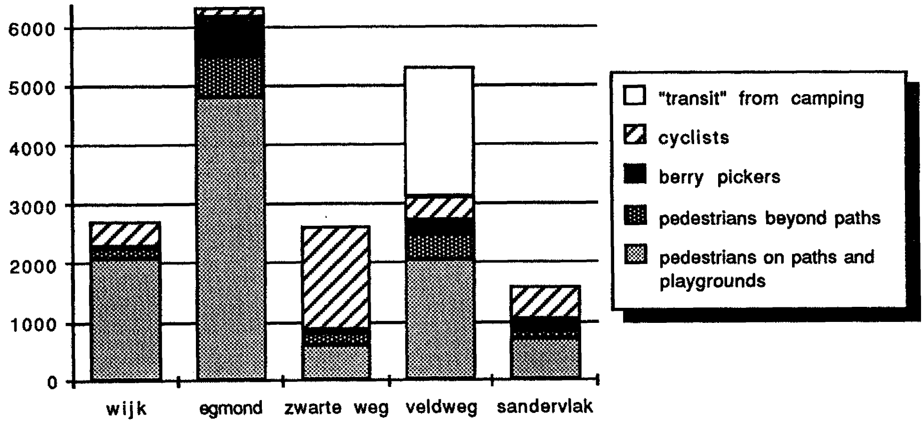


Figure 6.2. Numbers of visitors recorded in the five research sites.

Pedestrians beyond paths and berry pickers may be held responsible for possible damage to dunes and vegetation. Their numbers are large in Egmond and small in Wijk, Zwarte Weg and Sandervlak. However, if this category is calculated proportional to the total number of pedestrians per site, Zwarte Weg (34%) and Sandervlak (32%) show much higher proportions than Wijk (8%) and Egmond (22%). This difference is very significant ($p<0.001$, Wilcoxon). In Veldweg this percentage of pedestrians beyond the path is comparable to Sandervlak 31%. If the transit function is included, the Veldweg percentage compares to Wijk and Egmond (15%). Finally, the overall number of pedestrians beyond paths related to all visitors together is 9%; the percentage of berry pickers is 6%.

Impacts

In order to assess the extent and the importance of recreational impacts, we have recorded soil and vegetation parameters, together with recreation intensities, on various slopes and in flat stands (Van der Ploeg *et al.*, 1978; Ten Cate, 1979; De Jong, 1979; Van der Linden & Van der Ploeg, 1982). Although impacts probably occur everywhere, random sampling did not produce statistically significant differences. Only stratified sampling did; the applied stratification was a distinction between clearly visible (and *illegal*) "wild paths" and the rest of the stands ("non-path"). The importance of this distinction has also been proven by other research (e.g. Anon., 1977; Boorman & Fuller, 1977; Udo de Haes & Van der Zande, 1977).

At places where visitors frequently leave the "legal" paths, most illegal paths are found. We calculated a Spearman rank correlation coefficient of .67 ($p<0.01$) between the total number of recreationists beyond paths and the estimated length of illegal paths. A causal relationship could not be established, as rabbit grazing and other natural factors may influence the creation, existence and visibility of such paths.

Usually such paths are monitored by means of air photographs (e.g. Anon., 1977). Figure 6.3 shows examples from the sites Egmond (relatively crowded) and Sandervlak (relatively quiet).

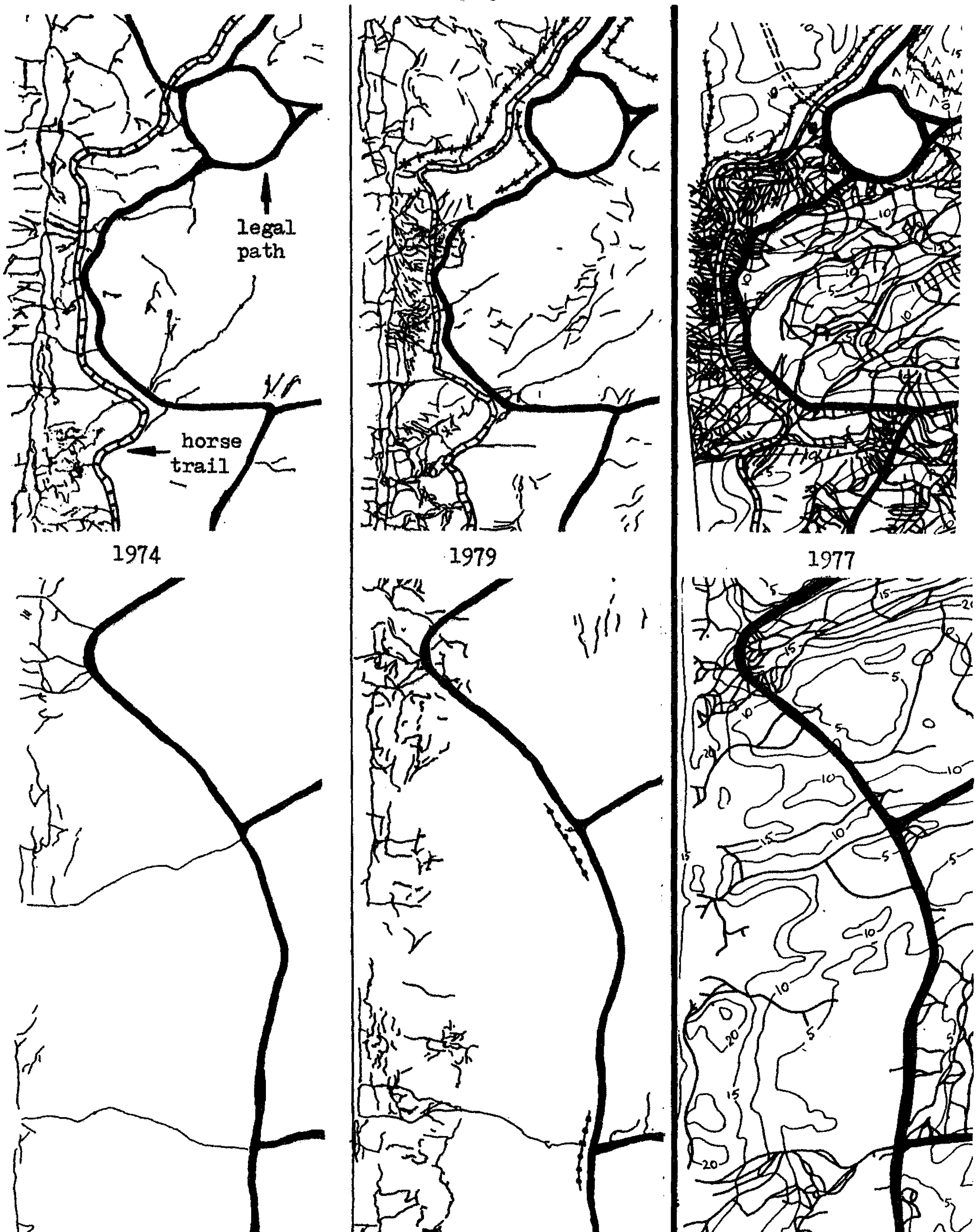


Figure 6.3. Illegal paths in parts of the research sites Egmond (top) and Sandervlak (bottom). Figures for 1974 and 1979 drawn from aerial photographs; figures for 1977 by field records.

In the field the extent of these paths appears to be much greater (right-hand drawings in figure 6.3). Moreover, path distribution appears to vary from year to year. Although it is tempting to attribute any increase in path density to increasing visitor pressure, natural factors may also considerably influence these densities.
Some characteristics of illegal paths and the surrounding vegetation are given in table 6.1 (see also De Jong, 1979; Van der Linden & Van der Ploeg, 1982). Bare ground surface, soil compaction and volumes of *Rubus caesius* and *Calamagrostis epigejos* show some significant differences. Other plant species only showed significancies in one or two stands (e.g. *Polypodium vulgare*: north; *Galium* sp.: south and flat; *Salix repens*: flat; *Festuca rubra*: south)*.

Table 6.1. Comparison of some path and non-path characteristics.

	north			south			east			flat		
Variables	path		non-path	path		non-path	path		non-path	path		non-path
nr. of species	41		33	16		16	23		23	36		31
bare ground	2%		0%	36%	*	4%	30%	*	1%	11%		1%
soil penetr. resistance(kg)	10.3	*	5.4	4.1		3.0	not rec.			12.9	*	3.9
Vol. Rubus(cm^3)	140	*	480	85	*	290	310		570	75	*	1023
Vol.Calamagr(cm^3)	2	*	8	2		3	0.1		4	3	*	41

* = significant at $\alpha = 0.05$ (Wilcoxon's two-sample, one-tailed).
Sample size n = 5 for each stand, for soil penetration resistance; n = 10 for the other variables.

Managing recreational use by zoning

The above impact assessments show that regulation of recreational use in favour of conservational goals makes sense, as it would at least enhance full performance of the vegetation. Then we may question *how* an effective regulation might be realized. We shall discuss options at three spatial levels: the area level, the site level and the spot level.

1. Zoning at the area level
Only some 10% of the visitors goes beyond the paths (page 99). This figure is comparable to situations in many natural areas in the Netherlands (Herbert, 1983). Most probably this is due to the explicit regulation to keep to the paths, in combination with a good patrolling by the wardens.
As regards the entrance fee as an instrument to regulate total numbers of visitors, the Schoorl State Forestry area and the "Dunes of Six", both neighbouring the NHDR, are free. However, there is not much difference as regards the frequency of visiting these areas (Anon., 1986); absence of

* A complete list of English and scientific names of plants and animals is given in Appendix A.

entrance fees appears to be only a minor motive to visit a dune area, as compared to amenity (natural beauty) and quietness. 55% of the visitors considers the fee to be low.

Entrance regulations and fees are only minor reasons for *not* visiting the NHDR. Only 9% of the respondents in a "home questionnaire" mentions this as important (Anon., 1986).

Most parking lots around the NHDR are located near the woodland parts of the area (see figure 5.3 for some examples). These are much less vulnerable for the mentioned impacts than the open dune parts, particularly the steep dunes near the sea. The majority of the visitors does not walk very far, and most of them will thus stay in the woodland parts (with the notable exception of Egmond; see below). Here also the majority of playgrounds is found and the number of paths is much larger than in the open dune landscape.

Figure 5.3 also shows some of the major cycling (paved) roads. Again the majority of these facilities is located in the woodland part of the NHDR area and along the woodland edges. Moreover, only few cyclists in the NHD also make a walk (5 %; Anon., 1979).

These different zoning measures are apparently coordinated and protect the open dune parts from visitor pressure to some extent. Although the woodland parts do contain conservation values most certainly, the open dune represents the more important conservation interests as regards flora and fauna.

2. The site level

In the five sites (see fig. 6.1) we assessed the numbers of pedestrian visitors leaving the paths in relation to the numbers of pedestrians staying on the paths (fig. 6.2). Table 6.2 shows figures for crowded and quiet *parts* of these sites, having in common that there is only one path present.

The pattern emerging from these figures is that "going beyond the paths" occurs proportionally more frequently in quiet (parts of) sites than in crowded ones. A possible explanation is that the visitors in the crowded sites are mostly "facility-based" recreationists, while the visitors in the quiet sites are "resource-based" (Van der Ploeg, 1986). The latter category may leave the paths more frequently as these visitors may want

Table 6.2. Pedestrian visitors (averages per observation hour) on and beyond the path in five sites in the NHDR.

	Wijk	Egmond	Zwarte Weg	Veldweg	Sandervlak
Site - path	14.7	37.1	3.9	30.5	4.7
- beyond	1.9	6.1	1.6	3.1	1.6
Crowded part- path	3.5	24.0	8.4	10.2	5.4
- beyond	0.2	0.6	0.6	0.5	0.4
Quiet part - path	1.1	14.0	1.3	2.2	2.2
- beyond	0.1	0.4	0.2	0.2	0.2

to use the whole site instead of only the part covered by paths.
Zoning at the site level by compulsory use of paths and roads thus appears to be partly effective. We also investigated how many pedestrians walked or sat *just beside* the paths (up to 5 m). In relation to the total numbers of pedestrians on paths this category amounted from 2-3% in the crowded sites (Egmond and Veldweg) to 7% in the quiet sites. These results again indicate a possible difference between facility-based and resource-based recreation.
In some sites, even path use is restricted. As already stated, the waterworks sites are not accessible to the public. These sites are only signposted; they are not fenced. Over a range of years we almost did not record any trespassing. Recently a part of the quiet site Sandervlak has been signposted as well, to provide a quiet area for various breeding birds, particularly the Curlew. It is reported that this zoning system functions properly (Slings, pers.comm.). People are asked not to enter this part of the site between 1 April and 15 July and during that period the paths are symbolically closed with a simple bar.
A rigorous application of zoning principles has been realized in the crowded site Egmond. As the managers argued that many dune slopes in that site were eroding, large parts enclosed by paths were fenced off with barbed wire. This proved to be very effective, as (in the parts of the site we investigated) 98% of the visitors kept out of these exclosures. However, some destruction of the barbed wire was reported and the wardens supposed that this was done by inhabitants of the village of Egmond who, by tradition, consider the dunes to be their ground.
In order to assess how effective such fencing is as regards the vegetation that is protected by it, we have compared two north slopes, two years after fencing one in an exclosure and one, just outside the fence, being accessible (although illegally). Table 6.3 shows some results from our observations in September, after the end of the berry picking period (see Chapter 5; in this period access beyond the paths is largely free). At the time of investigation, the exclosure had been established for two

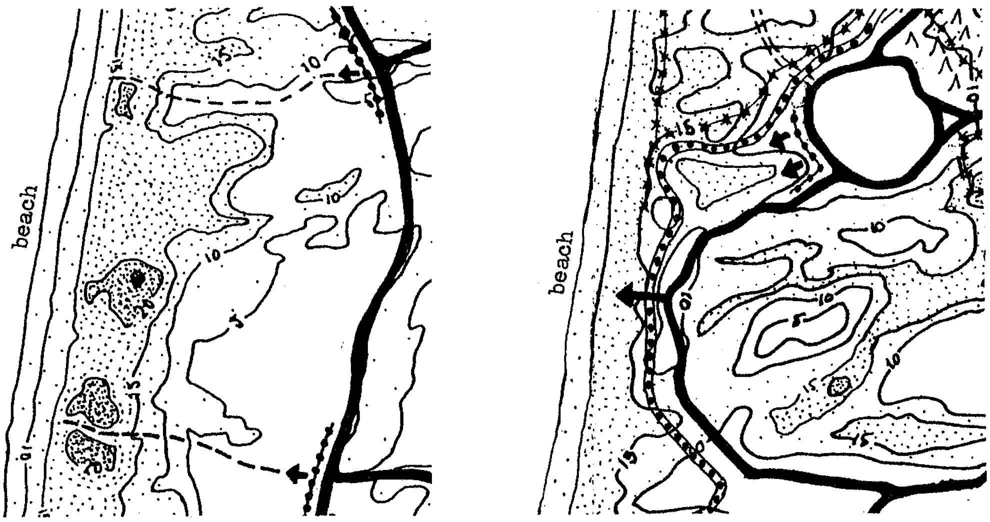
Table 6.3. Comparison of a north slope within an exclosure and an accessible north slope (data partly based on Rozijn, 1979).

	Accessible			Exclosure		
	path		non-path	path		non-path
nr. of visitors recorded		35			5	
extent of illegal paths	190 m	on	750 m²	200 m	on	950 m²
"new" paths	300 m			-		
bare ground surface (%)	1.4	*	0.5	0.2		0
soil penetr.resist. (kg)	10.3	*	5.4	11.3		7.6
average nr. of species	20.4		19.5	22.8		15.5
volume Rubus (cm³)	37	*	246	72	*	438
volume Koeleria (cm³)	16		23	11		5
volume Polypodium (cm³)	3	*	23	11	*	238

* significant at $\alpha = 0.05$ (Wilcoxon, one-tailed); $n = 10$.

summer seasons.
The effectiveness of the exclosure is clearly shown by the absence of new paths (i.e. almost no recent trampling has taken place). In both cases significant differences between path and non-path samples were found for some variables; the accessible stand shows a slightly more explicit difference. The differences between both stands (comparing "path to path" and "non-path to non-path") are partly statistically significant at $\alpha = 0.05$ (*Rubus caesius* on paths and beyond; *Koeleria cristata* and *Polypodium vulgare* beyond paths). This may be due to the short recovery period (two seasons). However, in Chapter 3 we have shown that in most situations the vegetation recovers very quickly. For many species recorded, differences found were nót significant. The average number of plant species present per sampling plot (0.25 m^2) also does not differ significantly between the various stands but is highest on paths in the exclosure.
Finally, exclosing visitors from certain areas has not always proven to be successful as regards nature conservation. In the Egmond site, large parts are still a remnant of the old situation near fishers villages where the people dried the nets and had their sheep grazing. After exclosure, this typical vegetation has changed into a more "natural" vegetation. Thus the manager has decided to apply mowing and grazing in order to preserve the specific vegetation present. It is admitted (Anon., 1986a) that some trampling by visitors may have had the same effect for a number of years. This is another argument for a deliberate choice if fencing-off is at issue.

3. The spot level
We experienced that people leave paths in particular if these paths are winding (instead of straight) and if paths come near spots where one may expect interesting landscapes etc. Figure 6.4 shows examples of spots where people tend to leave the path. The first situation is a T-crossing where people go straight on instead of choosing either arm of the T (left part of fig. 6.6). We have investigated two T-crossings. The second situation is where a path and a horse trail almost join. The horse trail bends off towards the outward dune ridge, the footpath runs back into the inland dunes (right part of fig. 6.4). People tend to take the horse trail in this case. The third situation is where the path is very near the outward dunes so that the sea can almost be seen. Visitors tend to walk over the outward dunes here in particular.
In all three situations the basic design could not be changed because the paths are part of the main network. Therefore the following measures were taken:
* at the T-crossings a wire (height 50 cm, no barbed wire) was set out along the arms of the T;
* at the joint of path and horse trail, a fence of barbed wire was placed between these for some distance;
* along the path near the outward ridge, nothing was done.



A B

Figure 6.4. Location of illegal paths. A: Sandervlak, B: Egmond.
horse trail — path — illegal path
wire — direction of leaving paths
existing barbed wire fence in Egmond

Table 6.4 shows the effectiveness in terms of changes in the ratio "visitors beyond the path" ~ "visitors on the path". Apparently such measures "on the spot" are effective, although to a different degree. They appear to be less effective than a complete fencing-off (see page 103).

Table 6.4. Effectiveness of taking small management measures: visitors that leave the legal paths (as percentages of total numbers recorded) (data partly after Rozijn, 1979).

	Before	After measures
T-crossing I	24.9 %	8.1 %
T-crossing II	10.2 %	1.5 %
Path/horse-trail	26.1 %	15.4 %
Path near outward ridge	30.3 %	34.6 % (no measures)

In the case of the T-crossings the illegal paths were also partly masked by creating small artificial dune ridges (1-2 metre high). Figure 6.3 (lower part) shows that the illegal path at the northern T-crossing has already become undetectable from aerial photographs after one year. Eight years after establishing this situation, repeated observation showed the following:

* most of the artificial small ridges were vegetated and were difficult to distinguish from the "natural" relief;
* the original illegal paths were still visible but were partly overgrown with *Rubus caesius* and *Salix repens*;
* new paths were created (more at T-crossing I than at T-crossing II), comparable to the paths characterized in table 6.1 (Flat stand).

Conclusions and discussion

As regards recreational activities that may have impacts on the resource ecosystem, the overall zoning measures for the NHDR appear to be effective. Where available, playgrounds are intensively used, and the percentage of visitors going beyond paths is low (9%). Yet impacts have been evidently recorded in terms of an increase in the number of illegal paths (fig. 6.3), the surface bare ground on paths on east and south slopes, an increase in soil compaction and a decreased vegetation volume (table 6.2). The number of plant species present has not been recorded to be affected by recreational impacts.
Zoning measures at the site level and the spot level are effective (in terms of reduction of the numbers of visitors going beyond paths), particularly if complete fencing is applied. Yet partial fencing may be preferred as this is also effective and does not affect scenic qualities very much. However, in that case fresh illegal paths will be created. Recovery of vegetation in exclosures is not spectacular and excluding most trampling may even cause disappearance of plant species that are characteristic for the vicinity of coastal villages.
The data shown have been recorded in a period that recreation intensities strongly increased (see next Section). Recent reports by the manager (Bonjernoor, 1984; Anon., 1985; Anon., 1987) do not reveal any serious increase of the impacts mentioned above. Efforts in favour of conservational use have increased in the same period and are reported to be successful (Anon., 1985; Slings, 1988). The overall picture emerging from this information looks like a stabilization of modest recreational use of the NHDR that generally does not compete with conservational efforts.

Impacts on vegetation and soil by recreation in dune areas in the Netherlands is well-documented (e.g. Van der Werf, 1970; Anon., 1977; Anon., 1978; Blom, 1979; De Knegt, 1979; Van Dorp & Van Dijk, 1982; Den Hertog, 1985). The same holds for the U.K. (e.g. Liddle & Greig-Smith, 1975; Pizzey, 1975; Boorman, 1977; Boorman & Fuller, 1977). Most of these publications stress the increase of bare ground surface (sometimes also erosion), increase of (legal or illegal) path length and width, soil compaction or erosion, loss of plant species and reduction in cover and height of the vegetation. In some cases these impacts can be documented in terms of a process (e.g. the extent of paths in the dunes of the Dutch Wadden Islands from 1970 to 1976, Anon., 1977; changes in vegetation in Meijendel between 1967 and 1975, Van der Werf, 1970, and Anon., 1978).

Most publications, however, concern the description and analysis of "impacts" (see also Chapter 3 for additional references on this topic) without an assessment of visitor numbers and changes over time. Yet the overall impression from the documents cited is rather alarming; in most cases stricter regulation of visitor pressure is considered a necessity to enable nature conservation. Interestingly enough, no recent documentation about the present *status quo* is available.
The most likely explanation for the discrepancy between this information and the NHDR data may be given by the overall visitor pressure and the effectiveness of zoning measures. Compared to other dune areas, visitor pressure is low (cf. De Knegt, 1979). As indicated, zoning is effective in the NHDR. On the Wadden Islands, in Meijendel and a number of other dune areas visitors may leave paths legally, with all consequences for the vegetation. In other areas (Berkheide, Kennemerduinen) visitors may not leave the paths but visitor pressure is much greater.
According to managers of a number of forested and natural areas in the Netherlands, zoning is an effective and a satisfying measure in regulating visitor pressure (Herbert, 1983). This is not always the case, as is documented for the Kennemerduinen. Zoning principles were applied here in an early stage (Roderkerk, 1961) and attracted international attention (e.g. Simmons, 1974). However, as increasing damage to the resource ecosystem was reported (Wijkhuizen, 1978), the manager needed to intensify the management by stricter regulations (as regards going beyond paths), by fencing off large areas and by "repair" measures.
Finally, Bayfield & Bathe (1982) have compared the effectiveness of six different barrier types for closing paths. They conclude that planks (with notice) and barbed wire are most effective (diverting 90% and 80% of the visitors, respectively). However, on wide paths and on paths with a clearly visible objective (comparable to our T-crossing I), most barriers (except planks) are much less effective if the alternative (free) path is narrower than or of similar width as the closed path.

Perception by visitors of changes in recreational use

As indicated in Chapter 5, certain recreational activities may influence other recreational activities. Sometimes this influence is just a matter of numbers (of visitors): people interested in silence and the absence of other human beings will move elsewhere if the number of other visitors exceeds their personal social capacity. Likewise, birdwatchers do not expect to be successful in a crowd of shouting children.
In recent years, jogging and fast cycling have strongly increased in the NHDR. These forms of recreational use are often a nuisance to both the category of "silence-lovers" and the category of visitors who enjoy the crowd. Both categories are disturbed, be it in completely different ways. A third "perception" aspect is formed by facilities present, and by all kinds of devices arranged in the area to direct the visitors (e.g. for

reasons of nature conservation or sea defence). Facilities like playgrounds, catering and "natural" ponds for bathing and swimming are usually meant to accomodate the so-called "facility-based" recreationist (Van der Ploeg, 1986). Simple facilities like benches and lookouts on dune tops can serve both facility-based and "resource-based" recreationists. The latter category will also be served by a design of the path network that gives an optimal opportunity to enjoy the resource (i.e. the particular properties of the *nature reserve*). An extreme category of resource-based visitors is formed by birdwatchers and other people interested in details of the wildlife; they often consider even the path network irrelevant for their purposes.
Finally, almost all categories of visitors may be irritated by service traffic and by elderly persons having a car permit for the reserve. This nuisance is largely limited to the hardened roads. Exclosures (in view of water-supply or conservational use) may also irritate visitors.

The issue

In areas like the NHDR two problems are prominent as regards the different categories of recreationists mentioned:

1) All categories may increase or decrease through time, thereby changing their "volume" of requirements (which are partly incompatible).
2) The manager is not entitled (for political reasons) to favour one category excessively, even while the NHDR is called a *reserve* and may obtain the NP status. At present, "quiet" recreational use forms are favoured but not exclusively.

The manager has already indicated several bottlenecks that they aim to remove (Anon., 1985): interference of recreational and service traffic; speed differences between racing cyclists and other visitors; marathons and comparable courses.
The manager would undoubtedly be cornered if the reserve would no longer serve the present range of recreational demands in their proportional intensities. Thus it is useful to answer the following questions:

1) What kind of motives are at issue in visiting the NHDR?
2) How do the number of different kinds of visitors develop?
3) Which signals are given as regards nuisance experience in the NHDR and as a motive for not visiting the reserve?

Information on motives, numbers, nuisance and non-participation

Information about the recreational use of the NHDR is scattered. Most reports published (Quarles van Ufford, 1964; PWN, 1971, 1972; Blok & Ranzijn, 1978; Vermeulen & Van der Ploeg, 1978; Anon., 1979, 1979a, 1986) differ as regards the research objectives, the questionnaire design, the sampling and the presentation. Thus the manager is confronted with ambiguous information on the questions stated above. Yet we may try to analyze the data in order to draw some tentative conclusions.

1. Motives for visiting the NHDR

Table 6.5. shows some motives recorded by means of questionnaires by Quarles van Ufford (1964) and Vermeulen & Van der Ploeg (1978).

Table 6.5. Motives of recreationists as recorded in the NHDR in 1962 and in 1976 (percentages of total numbers of respondents).

	1962		1976		
			Veldweg		Egmond
	at camping	elsewhere	campers	others	
nature & landscape	34.7	85.5	64.1	57.1	48.6
silence & quietness	...	...	27.6	44.7	39.9
fresh air	22.4	7.2	10.9	13.3	17.6
sociability	15.3	8.4	1.9	1.9	1.6
playgrounds	...	...	1.9	0	3.3
"away from ....."	59.2	20.5	1.3	10.5	3.3
other motives	48.0	16.9	25.1	19.9	21.8
(total n motives)	176	115	207	155	218
(total n respondents)	98	83	156	105	160

The visitors staying at the camping (for which the site "Veldweg" is the transit area to the beach) show a remarkable increase in their appreciation for nature and the landscape. They are less interested in "fresh air" and much less interested in "sociability". The (negative) "push" motives, notably "away from the big city, from the noise" etc. are much less important in 1976 than in 1962.
For the other visitors in the sample (stationary recreationists are *not* included in the table), interest in nature and the landscape have not really changed if we consider the "silence" motive part of it (this motive has not been explicitly described by Quarles van Ufford, 1964), being a "pull" motive: in the 1976 questionnaire, 77% mentioned one of these motives. There is more appreciation for the fresh air motive. Sociability and the negative "push" motives have become much less important. The category "other motives" is large because both reports indicate a number of non-comparable motives, e.g. "propriety" motives of house-owners in the camp (7%) in 1962 and "berry picking" (6%) in 1976.
The mentioned differences may be explained by changes in the residential situation in towns and cities between 1962 and 1976. Another explanation may be the increased mobility of the Dutch population, in conjunction with changes in leisure patterns.

In both questionnaires mentioned, "open" questions were used in asking for the motives for visiting the NHDR. In two home questionnaires, both held in the nearby villages Castricum and Egmond (Blok & Ranzijn, 1978, and Anon., 1986), "closed" questions were used (i.e. the possibilities of answers were defined and limited). Comparing results obtained by these two methods is reputedly difficult. Table 6.6 summarizes some results of the home questionnaires, held in 1977 and in 1983, respectively.

Table 6.6. Some motives for visiting the NHDR as recorded in home questionnaires (percentages)

	1977	1983
good opportunities for walking	28.4	67.6
idem for cycling		72.5
idem for race-cycling or jogging		22.3
playgrounds for children	22.3	23.8
quietness & silence	54.5	75.5
nature		64.0
amenity & landscape		46.1
letting out the dog	...	11.3
(total n respondents)	211	564

The qualities of the resource appear to be very important again (silence, nature, amenity). The facilities present in the NHDR (paths, roads, playgrounds) are also obviously appreciated. Because of the "closed" character of these questionnaires it is uncertain whether motives like "sociability" and "away from ..." still play an important role. However, the "playground" motive may incorporate some sociability aspects. Next, in another part of the 1983 questionnaire (including also respondents from the towns of Zaanstad and Alkmaar and referring to ten different recreation areas), 35% agreed to the statement that they appreciated the company of many other visitors, while 54% disagreed. As to the possibly related "away from ..." motive, the appreciation of "quietness" may be an expression for it (see table 6.6); in the whole questionnaire, 73% agreed to the statement that in a recreation area it should be very quiet, while 17% did not agree.
As regards the use of several facilities present, the results of the 1983 home questionnaire indicates that 47% of the visitors uses the guided (signposted) walks, 30% uses the playgrounds, 60% uses the lookouts and 47% uses benches (see figure 5.3 for examples of the distribution of playgrounds and lookouts).
In conclusion, visitors of the NHDR increasingly appreciate the resource aspects of the area and the present facilities; there is no reason to suppose that additional facilities (notably those aiming at attracting visitors that like the crowd) would be appreciated very much.

2. Trends in visitor numbers

Visitor numbers for the NHDR as a whole from year to year are not known. The best approximation for this may then be the yearly number of tickets sold which is registered in annual reports of the manager. However, we do not know exactly by how many persons the so-called "family tickets" (valid during one year) are used and how frequently these tickets are used. In an early report by the manager (PWN, 1972) and a later one (Anon., 1980) the group size was estimated at approximately 2.5 persons and the use frequency at 9 times per year. From the home questionnaire in 1983 (Anon., 1986), however, the conclusion was drawn that the group size was over 3 persons and the use frequency was almost 20 times per year. Figure 6.5 shows some trends in visitor numbers from 1960 to 1986. The figures shown are averages over three years. "Regular" visitors are calculated from sales of year tickets (assumed group size: 2.8 persons; assumed use frequency: 10 times, for retired persons: 25 times). "Incidental" visitors are calculated from sales of day tickets and week tickets (mainly used by holiday-makers; assumed use frequency: 5 times).

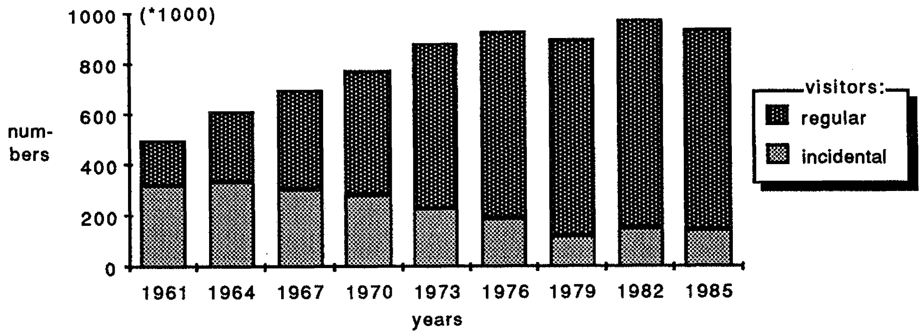


Figure 6.5. Trends in visitor numbers in the NHDR as calculated from ticket sales.

The number of incidental visitors has strongly decreased since the early seventies and is now constant. The number of regular visitors has strongly increased from 1960 to 1980 and is also constant now. The most recent figures (1984-86, and 1987; not shown here) show a slight decrease. We may therefore safely conclude that the strong growth in yearly numbers of visitors has ceased.

We assume that the regular visitors have good knowledge of the regulations and generally belong to the category of resource-based, "quiet" recreationists. From the respondents to the home questionnaire (Anon., 1986) in Castricum and Egmond, 81% used a year ticket. The profile of motives shown in table 6.6 is therefore largely connected with regular visitors. Visitors from Zaanstad and Alkmaar more often belong to the incidental visitors: 31% buys a day ticket; 25% uses no ticket at all (against 7% of the visitors from Castricum and Egmond).

3. Nuisance and non-participation

Nuisance by various features of the NHDR has been recorded by several questionnaires (Vermeulen & Van der Ploeg, 1978; Blok & Ranzijn, 1978; Anon., 1986). Table 6.7 shows percentages of respondents mentioning major nuisances (in terms of response). Nuisance by other visitors is mainly experienced as regards racing cyclists and the crowd as a whole. Both categories have increased from the early seventies to the early eighties. As to the regulations, only the obligations to buy tickets and to keep the dog on the leash cause substantial nuisance. Wires and fences seem to have been accepted through time.

Table 6.7. Nuisances mentioned by respondents to various questionnaires (percentages).

	1976	1977	1983
Nuisance because of:			
racing cyclists			12
too many visitors	5		11
litter	10	4	< 1
loose dogs	2		4
cars	< 1		< 1
wires and fences	6	5	2
entrance tickets	< 1	4	20
having to stay on paths	< 1	1	< 1
dogs must be on the leash	< 1	2	18
total number of respondents	429	211	989

In the 1983 questionnaire, respondents were asked to mention reasons for not coming to the NHDR. Important reasons (in percentages of 581 respondents) appear to be: lack of time (25%), more interest in other areas (21%), unability to go (18%) and distance (10%). The price of tickets only accounted for 5%, other regulations for 4%. Lack of facilities or dense crowds were almost not mentioned as reasons for non-participation.

Conclusions and discussion

The dominant motives for visiting the NHDR (walking, cycling, silence, nature and landscape) fit very well with the kind of outdoor recreation use forms preferred by the manager: quiet and resource-based. The facilities provided are simple and are clearly not a dominant motive for the majority of the visitors to come to the NHDR. Yet they are well-used and also from the use pattern (see previous Section) it can be concluded that they attract considerable numbers of visitors.
The rate of increase in total numbers has slowed down in recent years. If our calculations (fig. 6.5) are correct (but, as already stated, this is a low estimation and the real number might be twice as much; see Anon., 1986), the average number of visitors per hectare per year is 200 which is low in comparison to other dune areas. As some areas and roads (see the previous Section) attract very high numbers of visitors, other parts of the NHDR must be very quiet indeed. Yet 11% of the visitors holds the opinion that there are too many visitors (table 6.7). A further increase in total numbers would undoubtedly also increase this percentage.
Entrance tickets are a clear nuisance. However, this does not keep many people from visiting the NHDR. As such entrance fees therefore do not really regulate the total visitor pressure, but we do not know what would happen if no entrance fee would be required. Rather one could imagine that nuisance by trying to find out where to buy tickets (which is indeed a reported nuisance) could be overcome somehow. However, as the number of regular visitors (i.e. using a year permit) greatly exceeds the number of

incidental visitors, the issue should not have high priority.
Most nuisance is caused by dogs not kept on the leash, by joggers (and organized courses like marathons), and by race-cycling. As to the dogs, stricter regulation may be considered, e.g. by allowing them only in small sites near certain entrances. This would also facilitate the surveillance. As to the mentioned sports activities, special signposted courses may be laid out which should be segregated as much as possible from crowded roads and footpaths. This measure would, however, only partially solve the problems.

Questionnaires held in other dune areas (Voorne: Volker, 1969; Meijendel: Anon., 1978; NHDR, north part, and State Forestry area Schoorl: Louwen, 1977) all indicate the importance of nature, landscape and silence as motives to visit dune areas. Also visitor pressure is often considered high which is a nuisance (particularly in the Meijendel area). In all areas people complain about fenced areas but in all cases their numbers are low. Comparable results have been reported from other countries (e.g. Bayfield & Bathe, 1982).
As regards congestion, Van Alderwegen (1980) has suggested to estimate social capacity as a function of the average time lag between two subsequent encounters with other visitors. This may be a useful measure in comparing user satisfaction in crowded (e.g. Egmond) and quiet (e.g. Sandervlak) sites in the NHDR.

"Scars in the landscape": horse trails

Horse trails in sand dunes are usually completely bare, and the width of the trail may vary from one to five or more metres. No wonder that managers of nature conservation areas, but also managers of the sea defence dunes and those responsible for water-supply (dung!) are often ambiguous as to the decision to allow horse-riding.
In the NHDR, horse trails have been designed and signposted since 1964, a time when all kinds of outdoor recreation were enhanced. But in 1967 already, some trails were closed again or were rerouted in view of erosion problems and extensions of the waterworks. This redesigning of the trail network has continued since then.

The issues

As regards horse trails and, more generally, horse-riding in the NHDR, three issues are relevant. Firstly, although the demand for horse-riding in the NHDR is relatively constant (14,000 to 16,000 visits per year), the question stands whether a possible increase in demand must be satisfied or not. Secondly, even in the present situation extension of the trail network may be considered in order to bring the average density per trail to a lower level. Thirdly, trails crossing parts of the reserve

which are particularly vulnerable to erosion (notably the steeper slopes), might be rerouted to less vulnerable sites.
For each of these issues the first question to be answered is: what would be the impact on (specific parts of) the NHDR if the manager would open, close or reroute horse trails? Our research has focused on this question. A second question is: what are the social and economic consequences of altering the horse trail network, both for the users and for the manager? We also investigated this problem, be it in a more general way.

Ecological impacts of altering the trail network

In our research, we have focused on two matters of interest. Firstly, what happens to the dune ecosystem, if a new horse trail is created? Secondly, how does the trail recover after closing it? Combination of the answers on both questions can also show the consequences of rerouting trails.

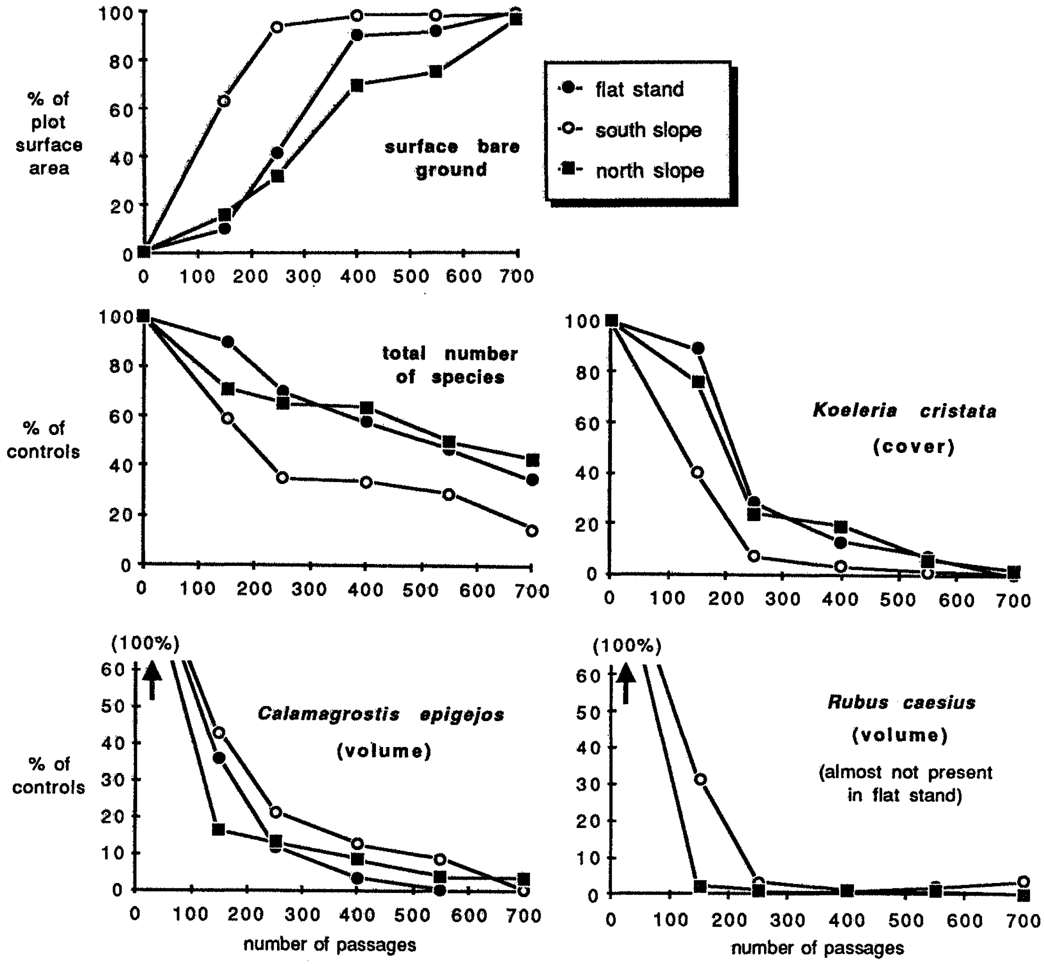


Figure 6.6. Impact of horse riding on surface bare ground and on performance of plant species (n = 10; averages shown).

1. New horse trails

On almost all soils, vegetation is soon destroyed when a horse trail is laid out. In our research (see Goede, 1979, for details) we have observed that a new trail, deliberately laid out over a small dune ridge, loses its vegetation for more than 90% on the south slope after only 250 passages of horses (see figure 6.6). On the north slope this amount of erosion takes 700 passages and on the adjacent flat area 400 passages. Trail width then is approximately 0.5 m, while bare sand has been kicked to the sides of the trail, covering another 0.2 m on both sides. Six months after opening the trail, its width is nearly one metre on the south slope. At that time, a gully of 0.3 m deep has been created in the top of the dune. Two years later, the depth of this gully is 0.75 m.

Disappearance of the plant species present has also been recorded. Figure 6.6 summarizes some of the research results. The total numbers of species recorded decline most on the south slope. Yet some species still survive after 700 passages, notably *Galium* sp. (11 in 30 samples) and *Rubus* (7 in 30), mainly on the north slope and in the flat stand. The average numbers of species per sample decline dramatically, varying from 0.5 on the south slope (control: 11.7) to 3.7 on the north slope (control: 16.8). These differences are highly significant ($p<0.001$; Wilcoxon). All three (dominant) plant species in figure 6.6 decline strongly after 150-250 passages. Performances on the south slope for *Rubus* and *Calamagrostis* look relatively good but this is due to the rationing to the controls (the south control performing much less than the north and flat controls).

Along with the recordings after 700 passages, samples have been taken at the edge of the path. Most species appear to be able to survive there. A comparison of controls, path edges and paths is shown in figure 6.7, south, north and flat stands being taken together.

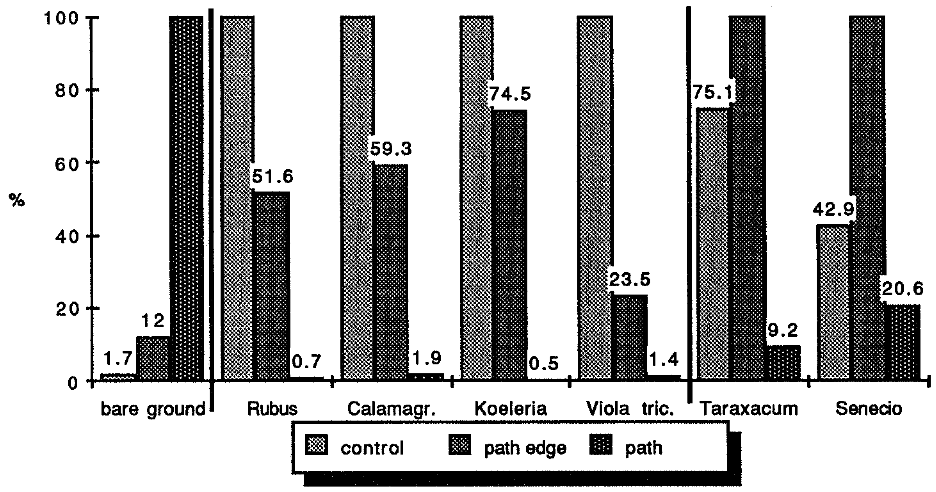


Figure 6.7. Relative performance of several parameters on, beside and outside a horse trail. All maxima set to 100%; bare ground and *Koeleria* as % cover, the other species as volume.

Path edges are clearly affected, mostly by horses beyond the path, by sand thrown from the path on the edge and probably also by pedestrians walking along the path (recorded several times). Some species, however, are apparently favoured by these conditions, e.g. (seedlings of) *Taraxacum* spec. and *Senecio* spec.

In comparison to the SR relationships shown in Chapter 3, horse trails apparently deteriorate very rapidly; no plant species appear to be resistant to this impact. Therefore SR relationships for horse trails are not really relevant, as complete destruction of the vegetation is inevitable. Thus the decision to lay out a trail is a very definite one.
Examination of existing trails, particularly those near the outward dune ridge, shows that, depending on the slope of the dune and the position to the prevailing wind direction (westerly), the depth of the trail varies from 0.25 m to 1.5 m. Where the trail runs *along* a steep dune slope (tangentially) "on the wind", erosion gullies of even more than 2 m deep and 5 m wide have been recorded. Thus the routing of the trail through such an area probably induces an erosion problem that may even be important in regard to the sea defence function of the outward ridge.

2. Recovery of closed trails
We have investigated the recovery of several closed horse trails in the NHDR for a number of years (see also Vera, 1978; Goede, 1979). Figure 6.8 shows some some examples of the recovery process. All trails are in flat areas. Most of them have been just left alone; in one stand (called "shoved"), the management has been to shove the vegetated edges of the trail into the centre of it and to cover the trail with dead wood (tree branches etc.), with the purpose to accelerate recovery.
Apparently a considerable part of the trail remains bare for a long time, as can be concluded from the slow increase in cover by vegetation. The unshoved stands recover faster than the shoved stands. Observations on comparable trails show that it does not really matter whether a trail has been used for only one year or for some years, as the recovery rate is comparable.
Total species numbers (and species composition) do not differ significantly between the trails and the controls next to it, after three spring/summer seasons of recovery (2.4 years in fig. 6.8). More conspicuous, however, are the differences in volumes per plant species. These volumes are significantly lower on closed trails for species like *Rubus*, *Calamagrostis* and *Koeleria* after four or more seasons. The height component of the volume is mainly explanatory for this difference. *Rubus* and *Koeleria* gain to a larger volume than the control after nine seasons (although not statistically significant), which may be explained by the pioneer characteristics of these species. The same holds for *Erodium* sp., *Senecio* sp. and *Taraxacum sp.* (seedlings) (data not shown).

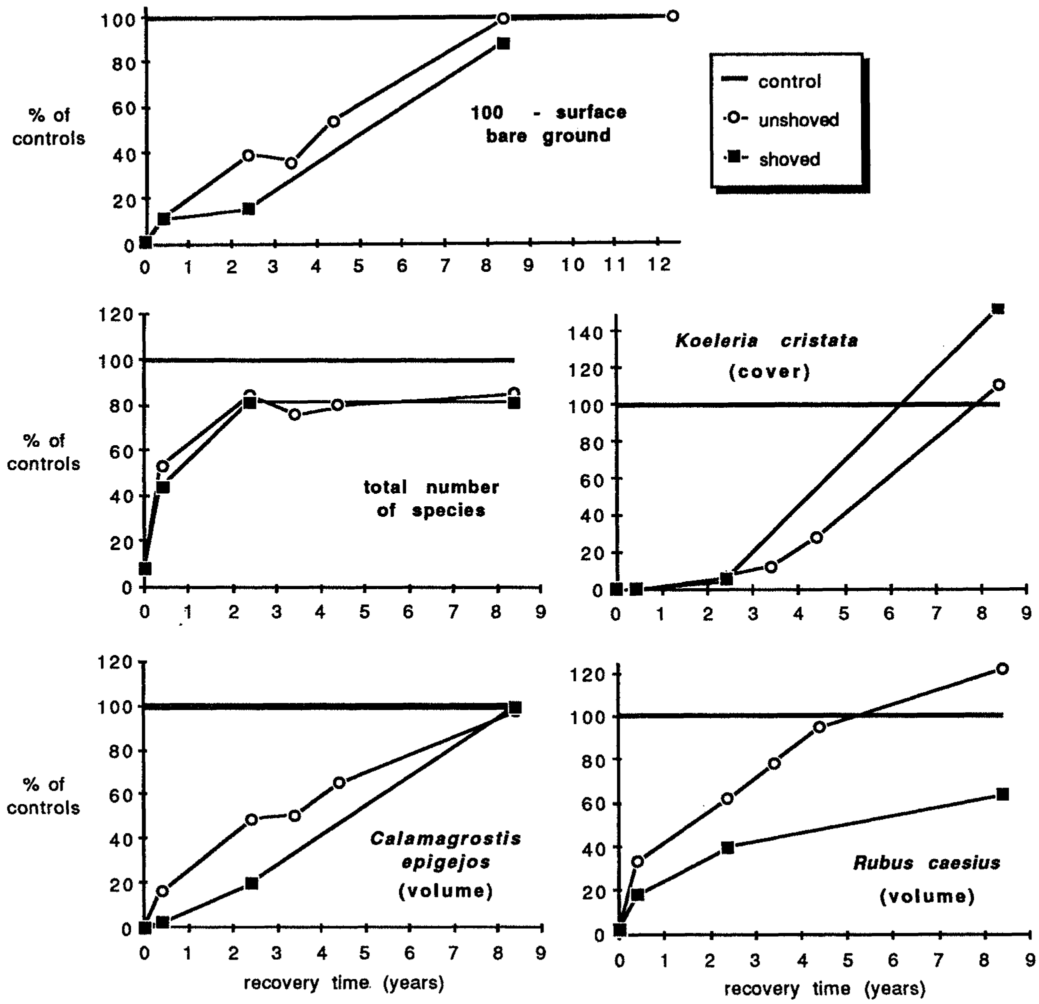


Figure 6.8. Recovery of closed horse trails (flat stands): surface bare ground and some vegetation parameters (averages from 10 sample plots per stand).

Unshoved trails perform better than shoved trails, except for *Koeleria*. For *Rubus* this difference is significant (α=0.05, Wilcoxon) after nine seasons, but this result may also be due to inhomogeneity in the stands sampled (n=10 for control, shoved and unshoved).
The considerable bare ground surface (i.e. the lack of vegetation or litter covering the soil) and the relatively small volume of the vegetation make a closed horse trail clearly visible, even after more than 10 years since closing it. We have not investigated very wide (1.5 m and more) trails but these may be expected to remain visible even much longer. When we realize that the dune ecosystems are relatively dynamic and therefore are likely to recover fast, this phenomenon is remarkable.
Finally, most parameters recover very slowly in comparison to vegetations trampled by walking persons (see Chapter 3). The change in environmental

conditions, notably the soil conditions, are assumed to explain this difference.

3. Rerouting horse trails
From the above it is easy to conclude that only in case of serious erosion risks rerouting of trails has to be considered. In all cases, rerouting means scars in the landscape that only very slowly disappear. No management techniques applied in the NHDR have proved to change this picture. Thus the intention of the manager to "...bring horse trails, where possible, nearer to other roads in order to remove less desirable intersections of the natural area." (Anon., 1985) certainly deserves reconsideration.

The *extent* of the ecological impact of horse trails in the NHDR is, of course, small, as the trail network is not extensive (64 running kilometres). Neither is the total use: at present this can be estimated at 16,000 horses per year. But even in this case the long recovery time is a warning against welcoming recreational activities with such dominant physical impacts like horse-riding. Comparable problems with motor crossing and off-road vehicles are wellknown from literature (see e.g. Godfrey *et al.*, 1978; Leatherman & Godfrey, 1980).

Other impacts of horse trails

The possible impact of horse trails on the sea defence function of the outward dune ridge has already been mentioned. Up to now, no serious erosion problems have been caused by the trails, mainly because they are designed just behind the outward ridge. Horses heading for the beach must cross the outward ridge via the transit roads for pedestrians. As these transits are intensively managed, the erosion risk is under control.
Eutrophication and pollution of surface water or physical damage to waterworks by horse riding may become important if the intensity of horse-riding would strongly increase. But even then the present trail network is distinctly separated from the waterworks areas, partly by rerouting some trails in the infiltration area near Castricum (on request of regional inspector for public health, see Anon., 1985). There seems no problem here; air pollution, mainly from the nearby industries, is assumed to be much more important for water quality.

Financial consequences of altering the trail network

As discussed above, the present trail network does not influence other use forms in the NHDR greatly. Thus there is no reason to reduce the network substantially. There is also no reason to redesign the network, particularly in view of the negative consequences of doing so. But what about adding new trails to the network?
If we assume that trail length increase is directly proportional to the

increase in sales of tickets, each percent increase in trail length (i.e. 640 running metres) would yield Dfl. 470 per year (1% of Dfl. 47,000, the average amount over the last few years). Maintenance costs may be estimated at Dfl. 200-300 (labour, materials, transport) and the construction of the new track would require at least Dfl. 1,000. Thus the net profit would not be high, certainly not in comparison to the total profit from ticket sales (Dfl. 861,300 in 1986). Also the profits for nearby manèges would not be substantial unless the trail network would be greatly extended and horse-riding would become much more popular (which is, at present, not the case in the Netherlands). As indicated above, "costs" in terms of scars in the landscape would be high.

Conclusions and discussion

New horse trails become bare after a relatively low number of passages by horses, in comparison to impacts by pedestrians (Chapter 3). The trail is almost bare after less than one season. Only very few plant species survive. Yet the total number of species recorded on these trails does not decrease equally dramatically, except on south slopes. Trail edges are also influenced, but here some species are favoured by the conditions.
Recovery of closed horse trails takes an relatively long time, again in comparison to footpaths. After ten years the trail is still visible but most plant species present have recovered (in comparison with control stands). The percentage bare ground surface has also strongly decreased after eight years; the number of species present is lower than in the control stand but this difference is not significant.
Technical management (shoving the edges of a closed trail into the centre) does not accelerate the recovery rate. Therefore closed trails may be just left alone, except some covering (with branches etc.) of tracks that have been badly eroded or have become very wide.
On account of the above conclusions, rerouting horse trails should be avoided as much as possible, in orde to reduce the number of such "scars in the landscape". As the use intensity of the horse trail network in the NHDR is low, extension of the network is not necessary and is certainly not advisable in view of natural and scenic qualities.
Weaver & Dale (1978) also compared impacts by horseriding on flat areas and slopes, in grassland and in woodland habitats. They found stronger impacts on slopes for all parameters recorded (bare ground, soil compaction, trail depth and width); impacts by horses descending from slopes exceeded those by horses ascending slopes. They conclude that slopes with an inclination larger than 16% should not be used for horseriding. Comparable results for mountain areas have been reported by McQuaid-Cook (1978) and Summer (1980). Hammitt & Cole (1987) state that sites in wilderness areas used by horse-riding parties are six times as large as backpacker sites, with a bare area four times larger. Such sites also contain numerous introduced plant species, spread by seeds in horse manure or by being stuck to the horses' bodies.

Dewberry picking

Dewberries (*Rubus caesius*) are dominant in large parts of the open dune. The species is fairly resistant to dry conditions of the environment. Only in some pioneer vegetations (outward dune ridge), on acid soils and in sites where seabuckthorn (*Hippophae rhamnoides*) is dominant, Dewberry is a "minor" plant species in the vegetation. The species flowers from May on, and the fruits are ripe from July to the beginning of October.
Berry picking in the dunes has a long tradition, connected to the life in the early coastal villages. The establishment of the nature reserve status has not broken this tradition in the NHDR. From 10 August to 10 September visitors are allowed to leave paths and roads for berry picking, in contrast with the rest of the year. Even in this "berry period" wardens are keen to check entrance tickets and to prevent non-pickers trespassing the rules. Visitors are occasionally fined and sent away from the grounds.

The issue

The next two quotations from papers presented by the manager (Anon., 1980; Anon., 1985) show some qualities of the dewberry picking issue:

> "Only the 'common law' that allows (....) going beyond paths and roads for picking dewberries, which of course causes damage, is subject to discussion from the viewpoint of nature conservation. Although disturbance of the fauna is to a certain extent acceptable as most young animals are self-supporting at the time, the massality of the pickers and the exhaustive way of picking means a certain impact on the natural value. Unless subsequent data would come available that indicate irrestorable damage by berry picking, the present regulation will be maintained." (Anon., 1980).
>
> "Particular attention is required for the regulation, based on an old tradition, to (....) allow (....) going beyond paths and roads for berry picking. It is understood that this causes local disturbance of the fauna and demonstrable damage to the vegetation. As yet sufficient arguments of decisive significance to break this tradition do not seem to be present." (Anon., 1985).

The Dutch texts translated here are formulated very cautiously, emphasizing the need for sound arguments for breaking the tradition of berry picking. Caution seems required indeed, as both the people and the politicians would probably ask for very hard arguments in case of termination. Table 6.8 shows a subjective choice of dominant aspects related to berry picking, and a qualitative presumption of their impacts in case of both alternatives, continuation or termination of the regulation exemption for it.

Table 6.8. Qualitative indication of possible impacts of continuation or termination of berry picking in the NHDR.

	Cont.	Term.
- impacts on vegetation; erosion	-/0	+
- disturbance of animals	-/0	+
- pollution/damage of water-supply sites	-/0	+/0
- erosion of sea defence dunes	-	+
- visual amenity for non-pickers	-/0	+/0
- berry picking pleasure	+	-
- (other) benefits of picking	+	-
- publicity for the NHDR	+	-
- costs of patrolling	+/0	-
- political debates	+/0	-

"+" stands for positive impacts, "-" for negative impacts, "0" -for no impacts (little or no change).

We shall try to analyze and evaluate the information on these aspects, in order to find out whether a conclusion about continuation or termination is possible. Before doing this, let us first have a look at the *intensity* of the phenomenon "berry picking". Table 6.9 shows an overview of recorded numbers of visitors and berry pickers in 1977.

Table 6.9. Recorded numbers of visitors and berry pickers in five sites in the NHDR in 1977.

	Wijk	Egmond	Zwarte Weg	Veldweg	Sandervlak
total nrs. of visitors (excl. August)	2145	4312	2252	4043	1084
total nrs. of visitors in August	616	2032	441	1280	529
total nrs. of berry pickers in August	26	551	58	135	153
berry pickers as % of totals in August	4%	27%	13%	11%	29%

The differences in total visitor numbers between the sites are largely due to site-specific factors. Egmond has by far the largest extent of paths (more than 9 km/km²), while in Veldweg the transit road from camping to beach accounts for a very large number of visitors recorded (47%). Sandervlak is a quiet site, attracting only 9% of the visitors (against 34% for Egmond). In August, 11% of the visitors come to Sandervlak (against 41% for Egmond); the site is second in berry picking density after Egmond. Dewberries are relatively not abundant in Wijk and Zwarte Weg which is reflected in the low numbers of berry pickers. Observations in the sites Egmond, Veldweg and Sandervlak in 1978 (data not shown) result into a comparable pattern of berry picking intensities, percentages being somewhat lower than in 1977.

In the questionnaire in 1976 (Vermeulen & Van der Ploeg, 1978), 13% of the respondents in Veldweg mentioned "berry picking" as an important feature; 60% of the respondents did so in Egmond.
If these percentages have remained constant (which is not known), the overall increase in the number of visitors to the NHDR shown in figure 6.7 leads to the expectation that the density of berry pickers has increased as well. This makes the issue actual once more.

Adverse impacts of berry picking on vegetations and soils

The dominant impact of berry picking on the vegetation is exerted by trampling, causing both direct damage to plants and changes in soil properties that induce changes in vegetation growth. The impact of taking away the berries on the nutrient balance of the ecosystem is considered negligible.
From a number of stands observed in view of impacts of berry picking (see Van der Ploeg *et al.*, 1978 and Rhebergen, 1979, for a full account), we have selected the following, contrasting ones:

* two north slopes in the site Egmond, one having been fenced and thereby "quiet", the other being relatively "crowded" (see also the Section on zoning);
* two south slopes in the site Egmond, one remote from paths ("quiet"), the other adjacent to the mentioned North slope ("crowded");
* two east slopes in the site Egmond, both in the outward dune ridge; one partly fenced and thereby "quiet", the other adjacent to a frequently used path and very "crowded" (see figure 6.4B, arrow mid-left);
* two flat stands: one in the site Sandervlak, being the more "quiet" one, the other in the site Veldweg, next to a transit road to the beach, being the more "crowded" one; the distance between these stands is only one kilometre.

Samples were taken just before the berry picking period started, and just after it had finished. On all slopes, illegal paths could be distinguished, some of them having become only established after the berry picking period. In the flat stands, no clear paths were recorded, although in some places trampled patches were visible.
Even in these contrasting stands, impacts from berry picking were not at all unambiguously detectable. This may be due to the limited number of samples per stand (10-16), in relation to considerable small-scaled differences in the vegetation. Nonetheless we shall give some examples to illustrate the issue. Some of these data have been reported already (Ten Cate, 1979; Rhebergen, 1979; Rozijn, 1979). For statistics, Wilcoxon's two-sample test or the Mann-Whitney U-test have been applied, using $\alpha=0.05$ (one-tailed).
As regards the average percentage *bare ground surface* per sample, almost all stands show average percentages less than one for the samples taken outside paths. Only on the very crowded east slope, more than 3% bare ground surface was recorded outside the paths. Data for the sam-

ples taken on existing and on "new" paths (i.e. not existing before the start of the berry picking period) are shown in figure 6.9.

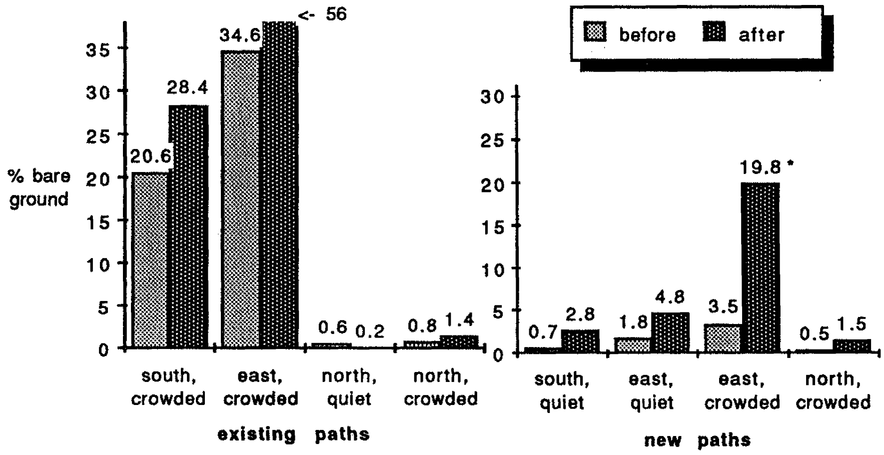


Figure 6.9. Average percentages bare ground surface on several slopes, before and after the berry picking period (n=10-12). *=significant difference at α=0.05.

The already existing illegal paths have become more bare (40-70% increase), except the fenced north slope. New illegal paths appear to have become much more bare than in the original (non-path) situation; surface bare ground has increased three to five times. Most bare ground is recorded on crowded south and east slopes; only on these slopes, the percentages on the paths are significantly higher than those in samples outside paths. Only the new path on the crowded east slope shows a significant increase in surface bare ground.
In both flat area stands, surface bare ground is less than one percent before and after the berry period.

The range of *numbers of species* per sample is different for the non-path samples from the four stand types: 16-20 on north slopes, 8-14 on south slopes, 5-8 on east slopes and 10-12 in the flat area stands. These numbers do not significantly change during the berry period.
Data for existing and new paths on the slopes are shown in figure 6.10. Average numbers of species are expressed as percentages of the numbers in non-path samples.
Changes in numbers of species on existing paths are not significant, except the increase on the fenced north slope. The decrease on the crowded east slope is nonetheless conspicuous. On new paths species numbers increase in three stands, of which only the increase on the quiet east slope is significant. Numbers decrease significantly on the crowded north slope. In both flat stands (not shown in figure 6.10) the species numbers increase (but not significantly); the increase in the "crowded" site is

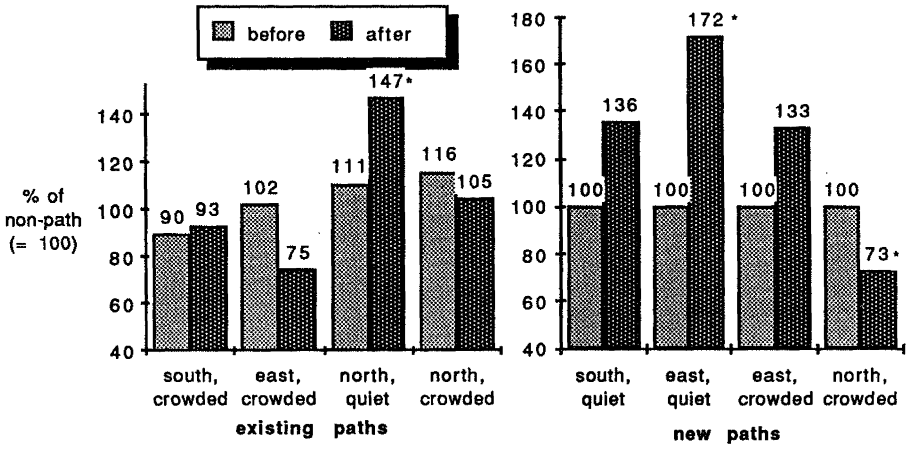


Figure 6.10. Average numbers of species per sample as percentages of non-path stands on several slopes, before and after the berry picking period (*=significant at α=0.05).

higher (32% versus 17%).
The higher numbers of species (in comparison to non-path samples) on existing paths on north slopes may be explained as caused by a relatively open and low vegetation, thus enabling more species to settle. Higher numbers on new paths may be caused by the *behaviour* of berry pickers walking on relatively open and low (non-path) vegetation and around dense and high vegetation. Hence the samples on new paths would naturally contain more species (even before the picking period) than the remaining non-path area. The differences shown may thus be caused by the sampling method. There is, however, no good explanation for the decrease on the crowded north slope (except methodical biases).

Also vegetation *volumes* of *Rubus caesius*, the dewberry itself, are affected by picking. In the non-path samples of most stands these volumes have slightly increased after the berry picking period. However, volumes on the fenced north slope have become significantly higher than those on the crowded north slope. In the flat stands the volumes of *Rubus* slightly decrease. Data for paths are shown in figure 6.11. Volumes of *Rubus* are expressed as percentages of the volumes in non-path samples.
Volumes on existing paths (as percentages of non-path stands) appear to remain constant, except for a significant decrease on the very crowded east slope. All volumes are significantly lower than the respective non-path stands. Volumes on new paths are also significantly lower than those outside the paths, and their decreases are significant as well. The crowded east slope decreases more strongly than the quiet east slope and this difference is also significant. The volumes in the crowded flat stand become significantly lower than those in the quiet flat stand (62% and 83%, respectively, as compared to the volumes before the berry period).

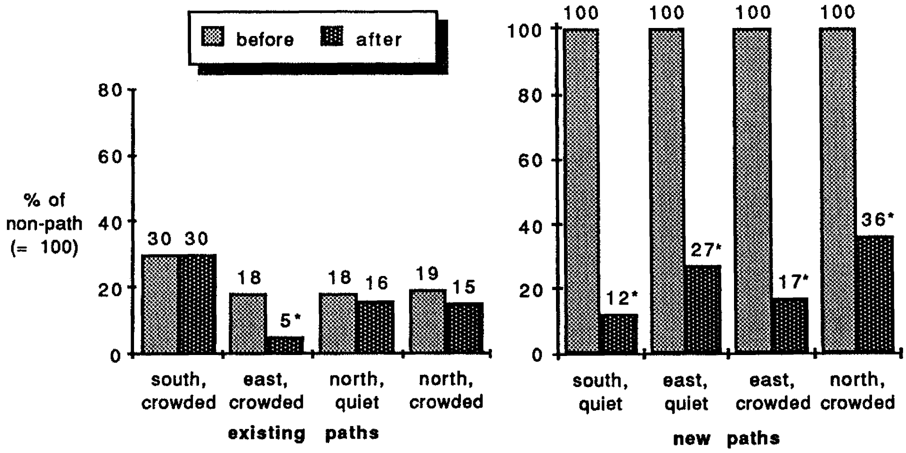


Figure 6.11. Average volumes of *Rubus caesius* per sample from paths as percentages of non-path stands on several slopes, before and after the berry period (*=significant at α=0.05).

Volumes of *Calamagrostis epigejos*, one of the tall grasses, are also influenced by trampling berry pickers. These volumes slightly increase in non-path samples from quiet stands but slightly decrease in crowded stands. Data for volumes in samples from paths are shown in figure 6.12. For the east slopes, data on the tall grass *Elymus farctus* have been used as *Calamagrostis* does not occur there.
Volumes on existing paths are significantly lower than those in non-path stands, except for the crowded south slope before the picking period.

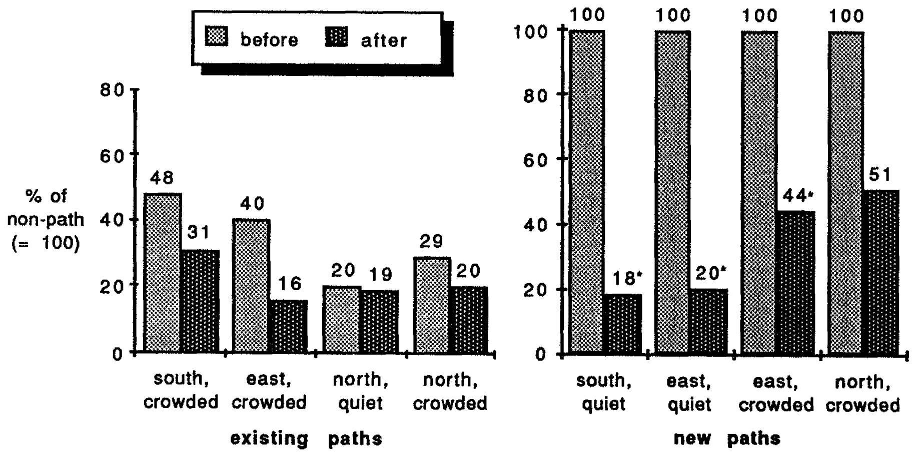


Figure 6.12. Average volumes of two grass species per sample from paths as percentages of non-path stands on several slopes, before and after the berry period (*=significant at α=0.05).
Calamagrostis epigejos on north and south slopes;
Elymus farctus on east slopes.

None of the decreases in volumes on paths is significant, but the fenced north slope remains constant in comparison to the crowded slopes. Volumes on new paths are significantly lower than those in compared non-path stands, except for the crowded north slope (probably due to the low presence of *Calamagrostis* on this slope). Decrease is more dramatical on quiet slopes than on crowded slopes, probably because volumes in non-path stands (the reference values for the percentages shown) on crowded slopes are relatively low. In the flat area stands, both categories slightly decrease. The decrease in the quiet stand is stronger but this is not statistically significant.

Many other species seem to behave like *Rubus* or *Calamagrostis*. We already have mentioned the example of *Polypodium* on north slopes (table 6.3). Some other species, however, notably *Galium* sp. and *Koeleria* (see table 6.3), seem to profit from path characteristics (open and low vegetation) and accordingly may do better on paths. This does not hold for newly trampled paths where all species appear to decline in their volumes. Most species, however, cover a large range of values recorded, both in path and non-path samples. Therefore statistical significance is seldom found.

The importance of the mentioned impacts can be analysed by taking into account the proportion of (existing and new) paths to the total surface of the stand. Figure 6.13 shows such proportions for four slopes, after the berry picking period. We have assumed that the average path width is 0.30 metre (in absence of detailed data). Figure 6.13 also shows the percentages of *Rubus* volumes actually left on the slopes after the berry period, assuming that a stand containing no paths at all would equal to 100% of the possible volume.
If we take the fenced north slope as a reference, only the (very) crowded east slope shows a substantially different pattern. Therefore the mentioned impacts on species must certainly be analyzed in their proportion

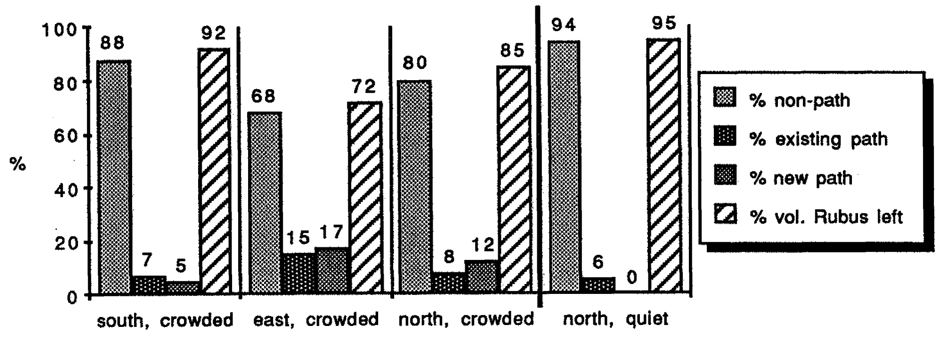


Figure 6.13. Percentages of non-path areas, existing paths and new paths, and the resulting percentage of *Rubus* volumes left on the stands (incl. paths) after the berry period.

to the stand (or even the site of Egmond) as a whole. Figure 6.13 suggests that the proportion of visible (i.e. paths) damage is low; the proportion of direct damage by berry picking (i.e. new paths) is approximately half of this visible damage.

Only little information is available about the *recovery* of slopes affected by berry picking. Data from three slopes have been obtained in the spring following the berry picking period in which the above data were recorded. Table 6.10 shows these recovery data in comparison with the data after the berry period (partly after De Jong, 1979).

Table 6.10. Recovery of various slopes in comparison to the situations after the berry picking period.

	south, crowded		east, crowded		north, crowded	
	"after"	recovering	"after"	recovering	"after"	recovering
bare ground (%)	28	36	37	30	1.5	2.7
species number*	93%	76%	106%	115%	86%	180%
volume of Rubus*	30%	49%	11%	42%	28%	33%
volume of Calamagrostis*	31%	73%	--	--	39%	36%

* expressed as percentages of comparable non-path stands.

Recovery is apparently different for the variables mentioned, and also for the different slopes. Bare ground surface has increased on South and north slopes. However, this is a usual phenomenon in spring, as cover percentages of most species are still low. The decrease of species numbers on the south slope is difficult to explain; one would expect an increase, comparable to the other slopes. Volumes of *Rubus* tend to recover on all slopes; the differences in *Calamagrostis* volumes may again be due to the low abundance of the species.
Observations after two and eight years of the "crowded" north and south slopes did not reveal any conspicuous deterioration. Although these observations were only simple (a few assessments of bare ground surface and *Rubus* volumes), they support the assumption (based on visual impressions) that these slopes have not really deteriorated.

Other possible adverse impacts of berry picking

Disturbance of animals by berry picking
No specific information about disturbance (or even killing) of animals by berry picking is available. From other evidence about impacts by trampling, however, the following indications can be given:

* a considerable amount of small animals (insects, spiders, mites etc.) will be disturbed or killed by trampling (see also Chapter 3). However, as the proportion of path surface to non-path surface is low (figure 6.13), no dramatic impacts on animal populations are expected;

* mammals (rabbits, foxes, mice) are almost not disturbed as they are primarily nocturnal (including dusk time);
* birds are certainly disturbed, e.g. *Oenanthe oenanthe*, *Saxicola rubetra*, *Sylvia curruca* and *Numenius arquata* (Van der Zande *et al.*, 1980). During the berry picking period, however, almost no birds breed (except for a few second batches) so that no impact on populations is expected. The impact on early migratory birds (e.g. warblers) is uncertain.

Impacts on water-supply sites
The water-supply sites in the NHDR are not accessible to the public. These sites consist of some reservoirs and the accompanying infrastructure. Parts of these sites are very good for berry picking. Although we did not systematically monitor berry picking in the waterworks sites, our incidental observations show that almost no berry pickers are present (1-2 per ha per day). Therefore no impact (damage, pollution) from berry picking on waterworks is expected.

Erosion of sea defence dunes
As already said (Chapter 5), the outward dune ridge is managed by the State Waterworks Service (SWS) as the sea defence for the hinterland below sea level. This part of the dunes does not belong to the NHDR but it is only partly separated from it by barbed wire. Thus berry pickers easily move from the NHDR to the outward dunes. The crowded east slope analyzed above is a good example. *Rubus* mainly occurs at the lee side of the outward ridge in a vegetation dominated by planted marram.
Erosion of the lee side almost does not occur in the region of the NHDR, probably because of intensive management by the SWS. In autumn and spring, however, parts are covered with sand blown from the beach and the windward side of the dunes by gales.
We have examined air photographs of the outward dune ridge, taken between 1974 and 1979. Although there is some tendency of erosion along the gulleys used as transit roads to the beach, there is no increase of erosion patterns during the years examined. At other places there is almost no sign of erosion at all. Paths in the outward dunes are usually bare paths. The fact that they remain identifiable over a range of years (De Jong, 1979) implies that they have not increased into a blow-out. This may be the result of the management.
In conclusion, berry picking, being only part of the recreational use of the outward dune ridge, is not considered to particularly influence the sea defence function as no obvious increase in erosion patterns can be assessed.

Negative recreational experiences
Probably not all visitors to the dunes like berry picking. In the results from all questionnaires held in the NHDR (see the Section on "Perception") no signals of nuisance (e.g. reduction of scenic or natural value

because of people spread all over dune tops and valleys) have been recorded. Some people ask for an extension of the berry picking period (Anon., 1986; less than one percent).

Adverse effects of termination

The far majority of berry pickers uses the fruits for private consumption only, e.g. for jams. Although there are no good estimates for the weight of berries consumed, we may consider the following data. In the months August and September the total number of visitors amounts 360,000 (low estimate). If we assume that only 50% of them takes away 200 grams or more (low estimate), the total harvest is 36,000 kg/yr at least. Next, if the additional costs for producing one jar of berry jam (from those 200 grams) are Dfl. 1.00, and one jar bought in the supermarket costs Dfl. 3.00, the net benefits amount at least Dfl. 360,000 on a year base. Travel costs and entrance fees are not to be taken into account as the average visitor numbers in this period do not significantly differ from other months in the period May - October.
A small number of visitors (2,000 - 3,000) in this period may be considered "professional berry pickers". They visit the NHDR several times in this period and often come from towns at a distance of more than 25 kilometers. As they can be seen taking away buckets of fruits, we may assume that they collect at least 10-20 kg per person. The net benefits for this group of visitors would then be at least Dfl. 200,000.
Apart from these tangible benefits (half a million Dutch guilders per year seems a minimum estimate), the majority of the visitors would lose at least part of their recreational experience if they were not allowed to pick the berries.
Termination of berry picking dispensation would thus probably arouse negative publicity for the management of the NHDR, and the Provincial Council would undoubtedly question the reasons for it. It would also take into account that the number of wardens patrolling in this period should double at least, costing thousands of guilders extra per year. Obviously the adverse effects of berry picking would have to be very prominent to convince politicians and administrators.

Evaluation

The information given on the previous pages is certainly not representative for all berry picking situations in the NHDR. However, the selected stands and visitor numbers are considered to represent both "quiet" and "crowded" berry picking sites. In terms of table 6.8, the following evaluation can now be done:
- The extent of illegal paths increases by berry picking. This is exemplified by an increased surface bare ground and by a reduced vegetation volume for a number of species. Only in the case of "new" illegal paths such changes are often statistically significant. The number of species

is not affected by berry picking. No erosion has been recorded. The surface of non-path vegetation still strongly dominates over the path surface after the berry period;
- Specific disturbance of animals by berry picking is probably limited to some bird species, but no good information is available;
- Berry picking does not affect the quality of water-supply sites;
- No specific erosion of the outward dune ridge due to berry picking has been reported;
- Berry picking is no apparent nuisance to non-pickers;
- Berry picking is an important activity in the NHDR in August;
- Private benefits from the berries may amount to half a million Dutch guilders per year;
- Costs of patrolling would increase with thousands of guilders per year if berry picking would not be allowed;
- The NHDR manager would probably suffer from negative publicity and political opposition.

In conclusion, the costs of continuing the berry picking permission would mainly exist of a part of the conservational use (in terms of performance of species rather than number of species) and a possible (because not revealed by changes in perception) reduction of the scenic value by an increased number of illegal paths. In view of the present benefits (or costs forgone) the permission should be continued.

There is no alternative to substitute the berry picking. Rather one could think about two supplementary options to minimize impacts on the dune ecosystem. Firstly, the manager may consider to reduce the "free period" to only three weeks. Even if this would not increase the pickers' pressure during those weeks, it remains difficult to see how this could be kept under control without a considerable surplus of wardening.
Secondly, fencing and signposting have proven to be effective in keeping visitors to the unrestricted areas, as we have seen in the Section "Zoning for conservation" (page 103-105). As to fencing, its effectivity may hold for berry picking (some 85% reduction, see table 6.3). Thus areas with a high conservation interest that are fenced off, will probably not be destroyed by berry pickers.

Water-supply, recreation and nature conservation

Water-supply has been a dominant use form in the NHDR since about 1850, next to agricultural use, hunting (earlier in this century), forestry and sea defence. Only after the Second World War nature conservation and outdoor recreation gained momentum. Water-supply has always been a vulnerable but vital use form, in view of the large number of people being strictly dependent on it. The political protection of and priority for this use form has caused serious problems for other use forms, some of which are briefly discussed here.

The issue

Water-supply activities in the NHDR originally only consisted of extracting groundwater from the dunes. As extraction exceeded the net accretion of the water reserve for a long time, in 1957 the manager started supplention of non-purified water by infiltration of surface water from the river Rhine. Since then, the groundwater table has risen again, be it different for various parts of the NHDR. All these activities may considerably influence the qualities of the vegetation and, consequently, the qualities of conservational and recreational use.
Because of the multiple use aims for the NHDR the manager has, of course, attempted to minimize negative impacts on conservational and recreational use by applying a range of management techniques. In the following analysis of the issue, we shall focus on two features important for conservation and recreation:
1) the surface area occupied by the water-supply activities;
2) consequences of extraction and infiltration for the qualities of the vegetation.

Surface area and activities

The total surface area of the two infiltration sites (see figure 6.1 for locations) and other waterworks is approximately 290 ha (Anon., 1985), which accounts for 6% of the total surface of the NHDR. However, both infiltration sites are located in the southern part of the NHDR (between Wijk and Egmond) in the open dune; they occupy some 10% of that landscape type. The southern infiltration area is not accessible to the public; the northern one contains two throughroads (one of them being a transit road to a quiet part of the North Sea beach).
Another area of approximately 50 ha near the northern infiltration site, "Watervlak" (see figure 6.1), has also been destinated as a potential location for waterworks, either surface infiltration or deep-well infiltration (see below). This would add another 3% to the open dune surface area occupied by waterworks.
Yet the present surface area is low in comparison to other water-supply sites in the dunes. According to Van Ommering (1983), the percentual surface area in the Amsterdam Water-supply Dunes is 25%, and in Berkheide (near Leyden) it amounts to 19%.
Both NHDR infiltration sites seem hardly suitable for any substantial conservational use, although the manager's reports (Anon., 1980; Anon., 1985) claim a certain function for breeding and migrating birds that rest and forage there. The argument that these sites were in agricultural use in the past (the same holds for the potential site Watervlak) does not convince as the manager has recently started an upgrading of the natural values (by means of mowing) of the Vennewater site near Egmond (Slings, 1988), which has also been used for agriculture. Even such sites may become valuable in terms of nature conservation in due time.

At least another 20 ha of the open dune has been dug out for pipelines. The majority of these pipelines run along existing roads (or even underneath them). In most cases, only traces of these pipeline trajects can be seen, as they are recolonized by vegetation.

The northern infiltration site is frequently used by recreationists (Anon., 1986). 86% of the respondents to the home questionnaire is aware of the existence of the site and 57% does actually visit it. The NHDR is associated with water-supply by 12%, next to associations with "nature" (22%), "recreation" (16%) and "dunes, beach and sea" (28%).
Almost no signs of nuisance with the present waterworks activities have been recorded, although the report on the NHDR home questionnaire (Anon., 1986) is vague about this: 8% of the nuisance response is not specified ("other"), and the work traffic of the waterworks company may account for one or two percent of these. However, almost no specific remarks about the waterworks have been made by the respondents. In the 1976 field questionnaire (Vermeulen & Van der Ploeg, 1978), 1% mentioned cars in the NHDR as a nuisance; this may also refer to car permits used by disabled persons. In both questionnaires, only one respondent considered water-supply activities in general as negative.

Consequences of extraction and infiltration

In 1956, dune **water extraction** had increased up to nearly 24 million m^3 per year. After starting infiltration (1957), this amount dropped to an average of almost 50% during the next ten years (Anon., 1980). At present, some 6 million m^3 of dune water water is extracted per year which is less than 10% of the total supply by the company.
Accordingly, the groundwater table had dropped in 1957 to almost five metres below surface in several sites (Anon., 1975). After reduction of dune water extraction, groundwater has rapidly risen to an average of three metres below surface. As a consequence, several dune slacks in the NHDR regained temporary wet conditions which used to be characteristic in the past.
In the first half of this century, a large part of the NHDR (ca. 800 ha) has been planted with Austrian pine *(Pinus nigra)*. These trees catch and use considerably more water than natural dune vegetations (including deciduous trees) do. As the coniferous woodland does not rejuvenate spontaneously and the manager does not yet intend to plant young pines (were it only because the costs of maintenance dramatically exceed the profits from sales; Anon., 1980), pine woodlands will gradually be replaced by deciduous woodlands, with beneficial consequences for the total water balance.
The vegetations of dune slacks, watercourses and small lakes that have been dessicated as a consequence of water extraction, are largely comparable to those of dunes that are naturally dry. Particularly most phreatophytes (plants associated with a high groundwater table) have disap-

peared. Table 6.11 shows some changes in the presence of phreatophytes in the NHDR between 1850 and 1978.

Table 6.11. Changes in presence of phreatophytes in the NHDR between 1850 and 1978 (after Bakker *et al.*, 1979).

	nr. of species	percentage
Disappeared	9	9%
Decreased	43	53%
Little change	8	10%
Increased	2	2%
Unknown	19	23%
Totals	81	99%

The wet habitats within the dunes constitute an important part of the conservational values of internationally renowned areas like Voorne's Duin (see e.g. Adriani & Van der Maarel, 1968). The lack of these habitats in the NHDR thus conflicts with several of the conservation options mentioned in this chapter (page 96).
The recent rise of the groundwater table does not automatically imply a recolonization by species that have disappeared or decreased in presence. Soils that become wet again tend to mineralize (Bakker *et al.*, 1979; Ernst, 1984) as a large part of the vegetation dies. This leads to a rough vegetation (dominated by shrubs, nettles etc.) and also to oxygen deficiency of the soil, which is no favourable condition for a number of pioneer species (Schat, 1982).
At present the manager is experimenting with two management techniques to recreate wet habitats with a number of phreatophytes. Firstly, several dune slopes are now allowed to blow out to the groundwater. Secondly, in some wet dune slacks the vegetation is mowed yearly in July. Both techniques are reported to be successful (Slings, 1988; Snater, 1988).

Infiltration with Rhine water eutrophicates the infiltration ditches and their vicinity. From Bakker & Van Dijk (1983) it can be concluded that nutrient loadings of infiltration sites by nitrate and orthophosphate exceed (calculated) normal values in wet dune slacks with a factor 20 (at average). Stuyfzand (1984) has reported a doubling of the nitrate concentrations in lysimeters in the NHDR from 1955/62 to 1980/83. Engelen (1984) indicates that the infiltrated water just below surface has spread over an area at least five times as large as the infiltration site.
This has resulted in a change in the composition of the vegetation; oligotroph species have disappeared and eutroph species (nettles, thistles etc.) have become dominant. To reduce this rough vegetation and the concentration of phosphates, Ernst (1984) suggests mowing in early summer and removal of the mowed parts, in order to maximize phosphate removal. Also purification and dephosphatization of the water before infiltration is considered important (see also Bakker & Van Dijk, 1983).

Yet restoration of infiltration areas seems difficult (Bakker *et al.*, 1979). The natural relief can hardly be restored; polluted soils from infiltration basins and surroundings must be removed; vegetation must be mowed or sodded regularly.
As to the presence of breeding birds in the infiltration sites, Udo de Haes *et al.* (1980) report that the number of species in the NHDR is lower than in "control" areas like Voorne's Duin and Zwanewater. This holds in particular for birds of marsh habitats (e.g. bitterns, snipes, warblers and crakes).

In the NHDR experiments are now started (in the site Watervlak) to explore the possibilities of deep-well infiltration (Anon., 1985). The surface area needed by this infiltration method is very modest; possible nutrients, heavy metals etc. would not influence the top layer of the groundwater. Deep-well infiltration may negatively influence conservational use as regards surface area loss (which may be confined to sites with few conservational values) and some disturbance of breeding birds by surface activities (Anon., 1983).

Conclusions

Water-supply activities are hardly in conflict with recreational use of the NHDR. In most cases, both use forms are indifferent or in cooperation with each other. Only the inaccessibility of the southern infiltration site means exclusion of recreational use. This would not have been the case if the existing northern site would have been extended eastward. Yet the southern site might be opened again for the public in due time.
Although water-supply and nature conservation do cooperate on the NHDR scale, they effectively exclude or compete with each other locally. In 10% of the open dune habitat, conservational use is almost excluded because of the intensively used infiltration sites; another 3% may follow in future. The waterworks infrastructure and the influence by polluted superficial groundwater account for another 40% of the open dune.
As deep-well infiltration would only satisfy part of the demand (which will also increase in future), the present water-supply infrastructure will be maintained for a long time. Conservation management will not be really effective in this case, so that half of the open dune faces a long future of competition between water-supply and conservational use.

Evaluation of multiple use in the NHDR

In the previous Sections we have discussed a selection of interactions between outdoor recreation, water-supply, sea defence and nature conservation. The general tendency of our conclusions is that the management has been successful in coping with many of the interactions, thereby realizing a multiple use situation which does not meet much opposition.

For completeness, we also stress the modest forestry activities (mainly aiming at creating a more natural woodland) and the policy to end agricultural activities. The following evaluation is confined to the four main use forms mentioned.

Summary of findings

Table 6.12 summarizes the various interactions between use forms as assessed in this chapter.

Table 6.12. Multiple use interactions in the NHDR.

IMPACTS ON →	Conservation	Recreation	Water-supply	Sea defence
ACTIVITIES: Zoning for conservation	X	LE	0	+
Recreation				
* walking	(-)	X	0	(-)
* horse-riding	LE	X	0	0
* berry picking	(-)	X	0	(-)
Water-supply	L-,LE	L+,LE	X	0
Sea defence	LE	LE	0	X

0 = indifference; + = cooperation; - = competition; E = exclusion
L = local; () = modest.

Water-supply is least affected by the other use forms, conservational use is most affected, be it only locally or modestly. Sea defence is only modestly influenced by some recreational use forms. Recreational use is locally excluded by the other use forms. The overall picture emerging from these statements is a relative stability in terms of sustainable multiple use: no use form is dominating so strongly that it excludes other use forms permanently or in large parts of the area. Yet we have some doubts about the impacts of infiltration of polluted water on conservational use in a long-term perspective, as the superficial groundwater is becoming polluted over a large area.
If no changes in use configuration (including intensities) would occur from now on, all use forms can continue to use the resources of the area without apparent depletion of resource stocks. In the present state (including management actions), the capacities of the area for this multiple use configuration are not exceeded. Yet only the aims and objectives for water-supply and sea defence are almost maximally reached; aims for various recreational and conservational use forms are only partially realized. At present there are no signs from the visitors (including those interested in wildlife) that this situation is undesirable; as regards conservational use, management actions are directed towards upgrading natural values (Anon., 1985; Slings, 1988).

Which actions needed?

The present multiple use does not require conspicuous changes in the whole of management actions now being taken. Conservational use is being enhanced (see above) and also a natural change from pine plantations into deciduous dune woodland is under way. Recreational use is not stimulated and it is only modestly excluded. Water-supply has not substantially increased as regards the extracted volumes and the surface area used. Sea defence still only regards the shoreline and the outward dunes.
We have discussed several possible management actions as regards their consequences for multiple use. Extension of zoning regulations by means of local exclusion of visitors does not seem necessary and reactions of the public on such extensions can possibly be expected. Facilitation of buying entrance tickets will certainly be appreciated by the public but may lead to increasing visitor numbers. Recreational activities like walking with dogs, race-cycling and jogging should be confined to special sites as they are a nuisance to the other visitors and also influence conservational use. Rerouting horse trails increases the number of scars in the landscape and should therefore be considered carefully. Restricting dewberry picking would meet political and social problems and would not increase conservation values substantially. Sufficient purification of infiltration water would be beneficial for conservational use.

The human population in North-Holland still slowly increases. This implies growing demands for both recreational opportunities and water-supply. These demands may also increase because of changes in leisure activities and in water consumption *per capita*. More intensive recreational and water-supply use can lead to a conflict with conservational use of the NHDR. The following management options for coping with this potential conflict can be suggested:

* Boundary areas of the NHDR and several adjacent areas can be made more attractive to visitors. This would imply a slight increase in the number of simple facilities but it would also fit into the present area zoning pattern. Activities like jogging and walking with dogs should also be situated in these fringe areas.
* Selective exclusion of both recreation and water-supply in certain zones. A high groundwater table would enhance natural values and would also discourage many visitors who do not like wet feet by walking through dune slacks. Dewberry picking could also be excluded locally.
* Entrance fees can be increased. Although this may not reduce visitor pressure considerably, the revenues can be used for further management actions.
* Deep-well infiltration can be extended. This is not necessarily to be done within the boundaries of the NHDR.

In all cases, the present trend to upgrade natural values of the Reserve is to be continued, as this can increase the satisfaction of many visitors and can also ensure a good quality of the freshwater reserve.

Constraints

The available information shows some constraints to management actions by water-supply use, by sea defence and by recreational use (notably dewberry picking). The following factors may also constrain management actions, possibly in due time.

* Maintenance of the area is already expensive, and the regional authority is keen on the budget (Van Gelder, 1984). If extra costs will be made for conservational use while recreational use is restricted, the regional authority will ask hard questions.
* Upgrading of natural values is a long-term process. Such activities may therefore become subsidiary to short-term political aims as regards water-supply and recreation.
* Deep-well infiltration only forms a modest part of the total water-supply: short-term increases in demand may necessitate the manager to increase dune water extractions. Possibly an increased water-supply from the lake IJsselmeer can satisfy the demand, but this is considered to decrease the present high quality of the water.
* The North-Holland coastline is still receding, and we also face a sea level rise as a result from the greenhouse effect (Anon., 1989). The inward dunes will therefore become more important for sea defence, possibly at the cost of all other use forms.

Another category of constraints would become prominent if the National Park option for the NHDR and the adjacent areas is to be realized. Recreational use would have to be restricted, particularly in crowded sites like Egmond. Dewberry picking may be a difficult issue in the negotiations about a possible NP. The two campings in the NHDR would have to be removed (maybe one of them could be excluded from the NP territory). On the other hand, no entrance fees should be charged. Water extraction would have to be reduced, and the infiltrated water would have to be purified much more than in the present situation. More generally, deep-well infiltration would have to be used much more. Other productive activities like timber production, agriculture and hunting would have to be terminated. The NHDR objectives mostly comply with this constraint. Finally, at least two main roads through the NHDR to the North Sea beach would have to be redesigned (if not removed) in order to preserve the ecological and landscape integrity of the NP as much as possible.
The case of the proposed National Park "De Zilk-Noordwijk" (Anon., 1989b) is illustrative for such constraints. The Committee for the National Parks has decided not to recommend to denominate this area as NP. Major reasons for this decision have been the presence of NP-incompatible touristic features (e.g. golf links), the primary of water-supply activities and problems in unifying management objectives of different owners and managers. Such a decision is understandable but is also regretted. The example of the NHDR shows that several "minor" use forms can go very well together in a multiple use configuration.

Gaps in available knowledge

From the examples given in this chapter, several gaps in the available knowledge emerge. Most of these gaps have in common that they refer to the lack of time series by which trends can be revealed.

* The patterns of recreational use are only known in general terms. It would be useful to start a monitoring programme for large parts of the NHDR. Rather than frequent questionnaires (a reputed nuisance to the public), periodic censuses should be done. Emphasis should be laid on **frequencies** per site or per spot rather than on absolute numbers.
* Impacts from "going beyond paths" and dewberry picking should be monitored by means of a limited number of indicators for a limited number of spots. Indicators that are simple to be recorded are conspicuous plant species and also bare ground surface. Length of illegal paths, soil compaction, plant species numbers and parameters for small animal species are relatively difficult to record. Numbers per species of breeding birds can also be monitored relatively easily but their relevance to multiple use management is not clear.

The examples in this chapter and in Chapter 3 show that the available knowledge on SR relationships and on recovery is insufficient, mainly as regards cause-effect relationships. Yet the question stands whether the manager would be better off with more scientific information. As the effectiveness and the acceptation of management actions seem to be the most prominent signals to the manager, we tend to advocate a greater attention for integrated management-response relationships. These can be assessed by monitoring both use patterns and the consecutive ecological changes. If the management action and these changes are carefully documented, notably by systematic recordings of what happens, such knowledge can hardly be overestimated.
We have deliberately **not** applied the simple IMR simulation model from Chapter 4 to the issues discussed in this chapter. The data basis for human population size, numbers of visitors, participation and water-supply issues may be sufficient, the data basis for actual trampling and the subsequent reactions of ecological parameters is certainly not. Yet we believe that such model types are useful as a framework to integrate management actions, use patterns and ecological responses.

Finally, we have not tolled the alarm-bell for management action, as our data did not necessitate that. The question remains - and we cannot yet answer it - when that bell should toll. Which minimum level of conservational use and of recreational use (to name the most affected ones) should urge the alarm? If the performance levels for various use forms that we have measured still hold, no further action seems required. But such a decision is up to policy-makers, not to scientists.

7. THE CASE OF THE NATIONAL PARK "DE BIESBOSCH"

This chapter deals with several multiple use issues in the denominated National Park De Biesbosch. As in the case of the NHDR, the interactions between recreational use, conservational use and water-supply form the major part of the analysis.
In contrast with the findings in the preceding chapter, the management issues selected here (zoning for conservation, changes in recreational experience, local damage by tourists, impacts on bird populations and water-supply) are regarded relatively serious and urgent by some parties. The research data on use patterns, perception, stimulus-response relationships and recovery, however, only partly confirm this concern. Thus the managers will have to decide upon the discrepancy between obviously contrasting opinions and the data. Various management options, including integrated management-response relationships, are reviewed as regards their usefulness for dealing with interactions between use forms. Finally, several gaps in the available knowledge are discussed.

Introduction

The information about the proposed National Park De Biesbosch given in Chapter 5 already indicates that the future managers of this wetland area will have a difficult job to reconciliate all use forms. The present ownership and management situation is such that straightforward policies might be counteracted by many governmental and non-governmental pressure groups. Most use forms can be regarded as based on historical rights, whether or not legal. Yet the NP status will require a vast amount of changes in the use intensities, with notable preference for conservational use and for non-intensive, resource-based recreational use forms.

Multiple use problems in other wetland areas

Most wetlands in the Netherlands and in other countries are used in a variety of ways, e.g. for dwelling (houses and boats), for fishing and hunting, for coppicing willows and other trees, for transport, for recreational purposes and for nature conservation. Many of the present Dutch wetlands are not natural but are man-made, e.g. by digging peat or by partly reclaiming land.

In the past, few serious problems caused by this multiple use have been recorded in the Netherlands. Many use forms, however, have been intensified and speeded up (in particular since the Second World War) and this has caused an increasing pressure on less prominent or less economically important use forms like nature conservation. A selection of examples is given below. An important notion is that wetlands always consist of water bodies and land surface (islands, surrounding shores or banks). Many problems occur at the interfaces of water and land.

Water management
Usually wetlands are part of a large water management area. In the past, draining of wetlands was important to guard the hinterland from flooding. Nowadays intensive agriculture often requires lower water tables; the draining may lead to considerable changes in the proper wetlands if no specific measures are taken (e.g. special water management systems, as in the case of the nature reserve Naardermeer).

Outdoor recreation
Water-based recreation has boomed in popularity since World War II. The increase in numbers of recreationists and in activities does not only affect ecosystems (in terms of damage and disturbance) but has also led to conflicts with most of the other use forms in wetlands. Established recreational use forms like sailing, rowing and canoeing now compete with relatively recent activities like motoryachting, waterskiing and surfing.

Transport
Although the number of commercial ships sailing through wetlands has decreased rather than increased in the past forty years, their volume and their speed have certainly increased. This has an important impact on conservational use of the aquatic ecosystem (including banks and shores that need to be strengthened) in terms of waves and turbulence, but also on other use forms. Increasing traffic (cars, bicycles) along wetlands may locally disturb the fauna. So do increasing numbers of small airplanes, particularly when at flying low heights.

Exploitation
Fishing has never had considerable influence on fish populations of wetlands in the Netherlands. Hunting, however, together with changes in habitats (e.g. by water management) has reduced the fauna of wetlands in species richness and in numbers per species. In the past century the Night Heron* was a common bird in many wetlands in South-Holland. At present, only a few breeding pairs in the nature reserve Nieuwkoopsche Plassen and in the Biesbosch have remained.

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* Appendix A contains a complete list of scientific and English names of plants and animals.

Willow coppicing and reed cutting can keep the ecosystem in a cyclic succession. As this exploitation is usually rotational, it is beneficiary to the variety of succession stages. However, it may temporarily disturb wildlife and also recreational experience.

Pollution
Pollution is a kind of use form where areas are used as a substrate to receive waste substances. Wetlands are nowadays threatened by water pollution (nutrients as well as toxic substances) and air pollution (acidification and/or eutrophication). Refuse tips and dumping of chemical waste are threats that have been revealed recently.

Nature conservation
Wetlands have been recognized early for their wildlife interest; the Naardermeer as the first nature reserve in the Netherlands has been established in 1906. In some cases the protection of natural values has led to exclusion of most other use forms. At present, "wise use" of wetlands is being advocated, being their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem.

Outline of this chapter

The above examples show a variety of situations in wetland areas where competition between or exclusion of use forms exist. In the case of the Biesbosch we shall illustrate and analyze some of these interactions by looking at the impact of changes in a particular use form on other use forms. As regards nature conservation, zoning measures are analysed; as regards recreational use, we have selected visitor perception, local damage by visitors ("tourist spots") and impacts on bird populations; as to water-supply, area demand is discussed.
These examples will be dealt with like we did in Chapter 6. First, the management issue is defined and some background details are given. Then the issue is analyzed with available data and with reference to Chapters 2-5. The chapter concludes with an evaluation of the multiple use issues.

A large part of the information presented here is based on original research (both field work and desk research) done in 1982-1984. A series of reports (Braat *et al.*, 1984; Van der Linden & Van Eijk, 1984; Van der Ploeg *et al.*, 1984; Saris & Van der Salm, 1984; Saris *et al.* 1984) has been published in Dutch language, the main research report (Van der Ploeg *et al.*, 1984) being an extended summary of these. However, many other reports on the Biesbosch NP multiple use issue will also be cited frequently, as these are a necessary supplement to understand the problem properly. Most of the research information focuses on conflicts between only two different use forms; therefore conclusions about multiple use are merely deduced from this information and not derived from specific multiple use research.

Acknowledgements

The original research has been done by a team from the Institute of Environmental Studies of the Free University and the Study and Information Centre for Environmental Research of the Organization for Applied Scientific Research (Delft, the Netherlands). I particularly thank Leon Braat, Theo van Eijk, Wouter van Heusden, John van Huis, Cees Kwakernaak, Wal van Lierop, Joop van der Linden, Mike Janssen, Jacques van der Salm, Frank Saris and Peter Visser for their research efforts. The research has partly been sponsored by the Committee for National Parks of the Netherlands and by the Department of Agriculture and Fisheries (Directory for Nature Conservation and Outdoor Recreation).

Zoning for nature conservation

From a conservationist point of view, a large part of the Biesbosch should be a strict nature reserve, without almost any other use form allowed. Such a status would benefit the establishment or introduction of a number of rare bird and mammal species like Little Egret, Spoonbill, Osprey, Otter, Beaver and possibly Elk (Anon., 1982). As regards the vegetation a reserve status would not be necessary. At present a relatively small part (20%) of the Biesbosch has the reserve status.
Recreational use is subject to sailing regulations which are in fact zoning measures. The most important regulations will be discussed below. A second category of zoning features consists of the areas where no access is allowed: nature reserves, water-supply areas and some parcels of agricultural land. A third category of zoning features is formed by areas that are physically impossible to enter: very shallow creeks and other creeks that are only accessible to the smallest boat types. Finally, tourist facilities (mooring places, beaches, playgrounds, viewpoints) attract visitors. The resulting recreational use pattern is therefore not random but clustered.

The issue

The debate about zoning of recreational use of the Biesbosch has a long history. From 1970 on, yachting societies have been fighting against increasing land use by the water-supply company and by the nature conservation managers. Sailing regulations were established in 1975 and were tightened up in 1983. At the time of our research (1982-1984), the conflict escalated because of the debate about the possible NP status of the Biesbosch. Incidentally we experienced signs of a "civil war" between recreationists and conservationists lobbies.
In 1985 the Committee for the National Parks of the Netherlands has presented an advice about the Biesbosch (Anon., 1985a). In this advice another tightening up of the regulations is proposed, aiming at the esta-

blishment of large conservation areas within the Biesbosch where only few recreational activities will be allowed (see Chapter 5, fig. 5.6).

The sailing regulations of the Biesbosch indicate the permitted type of use for each of the watercourses and the adjacent land. Four categories of watercourses are most important:

1) waters with free access and free mooring (no access to the land except at tourist facilities);
2) waters with free access but no mooring for motorboats with cabins;
3) waters only accessible for non-motorized boats (no access to the land);
4) waters not accessible to the public.

All zoning measures have been based on thorough consultations of all parties concerned, and also partly on results of research. Yet the question remains whether another change of regulations (in relation to the NP status) is necessary and will be obeyed by the visitors. In other words: how can multiple use of the NP be optimized, accepting conservational use as the main important use form, without increased partial exclusion of recreational use in particular?
To answer this question we shall analyse present recreational use patterns in relation to the regulations and we shall try to look into the possible future by scenario analysis. This Section particularly deals with patterns of outdoor recreation; next Sections will be devoted to the evaluation of conservational benefits from zoning.

Patterns of outdoor recreation

Recreational use of the Biesbosch has strongly increased over the past 15 years. Particularly after the closing of the Haringvliet dam (see Chapter 5), the Biesbosch came available to a large number of boats, notably cabin-boats. Figure 7.1 indicates the national increase in sailing movements compared to passages through three locks in the Biesbosch (after Anon., 1983a; Kosters, 1987; De Ridder, 1987).

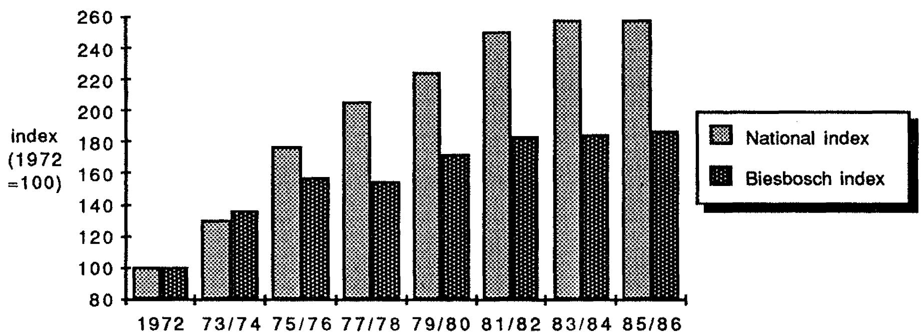

Figure 7.1. Trends in recreational sailing movements for the Netherlands and for Biesbosch locks.

The strong increase in the period 1972-1982 seems to have ended, nationally and particularly locally. This may, however, be due to the fact that many summers since 1980 have been relatively cool and wet. The Biesbosch index clearly lags behind the national index, possibly because in summer the maximum capacity of the locks is reached.
In 1975 already a number of visitors of the Biesbosch considered the recreational use intensity too high for undisturbed enjoying the nature and the landscape of the area (Anon., 1976). The increase indicated in figure 7.1 may have intensified this type of conflict.
The estimated total numbers of boats in the Biesbosch in 1983 are shown in figure 7.2 (Van der Ploeg *et al.*, 1984a). Numbers are based on moment countings from sailing boats (twice per day on eight days). Van der Voet & Smit (1982) indicate that this method implies an underestimation of 20-25%.

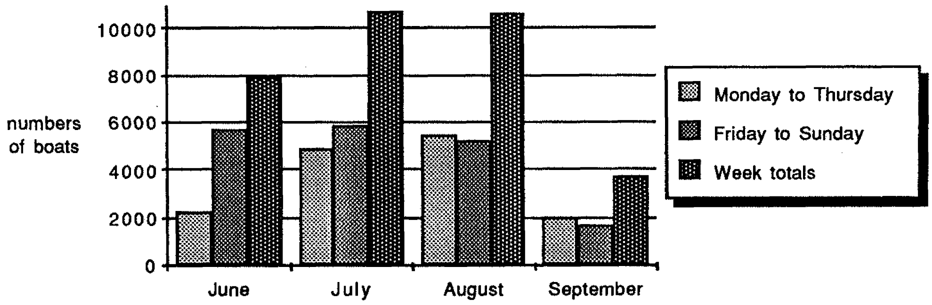

Figure 7.2. Estimated numbers of boats visiting the Biesbosch in different months in 1983.

From the total number of boats counted at one specific moment, only 19% is actually sailing; the other boats are moored or anchored. This picture is supported by results of a questionnaire carried out in 1983 in the Biesbosch (Van der Linden & Van Eijk, 1984): 61% of 397 respondents indicated that they sailed less than one hour between 10.00 and 17.00.

Table 7.1. Main categories of boats in the Biesbosch (percentages).

	Not Sailing		Sailing		Total	% in questionnaire
Cabin-boats	61.4		9.1		70.5	72.9
Open motorboats	8.6		3.9		12.5	8.6
Rowing-boats/canoes	6.2		1.9		8.1	5.6
Yachts	2.0		1.6		3.6	10.6
Surfboards	0.8		1.4		2.2	0.5
Commercial vessels	2.4		0.6		3.0	1.8
Total %	81.4	+	18.5	=	99.9%	100%
Total n	13198	+	2999	=	16197	397

The Biesbosch is used by a variety of boat types. Main categories are shown in table 7.1. Cabin-boats appear to be the far majority. Most of them have been recorded while not sailing (87%). Open motorboats are relatively dominant, as their numbers are almost equal to the total numbers of non-motorized boats (12.5% against 13.9%). Only yachts and surfboards are relatively active (44% and 64% recorded sailing).
Recorded percentages for non-sailing yachts may be lower than in reality because of observers' biases. From parallel observations by taking air photographs, however, we have estimated that this bias would add only 1-2% to the non-sailing yacht percentage, at the expense of the cabin-boat percentage.
In the questionnaire, yachts are represented disproportionally high. The reverse holds for surfboards. The other categories show lower proportions than actually present (60-70%). The results of the questionnaire are thus slightly biased and should be used cautiously.
In order to obtain information about possible **spatial** relationships between these boat types and also between various activities, factor analyses have been done. The analysis for moored and anchored boats results into a distinction into three groups (factor loadings* between brackets):

1. Cabin-boats (.78) with activities in water (.73) and quiet activities on land (.76); to some extent "unquiet" activities on land (.45);
2. Rowing-boats and canoes (.99), to some extent open motorboats (.47), and "unquiet" activities on land (.42);
3. Open motorboats (.67) and fishing from the boat (.68).

Yachts and surfboards cannot be specifically attributed to one of these factors (but relatively more to 1; .30 and .30, respectively).
Among the recorded boats sailing, two groups can be distinguished:

4. Cabin-boats (.92), yachts (.52) and open motorboats (.47);
5. Surfboats (.75) and yachts (.59).

Rowing-boats and canoes cannot be placed in either of these groups, probably because only few have been recorded while sailing.
Group 1 can be interpreted as representing the majority of the tourists on freely accessible waters. Group 2 consists of small boats that are probably moored in small creeks where no mooring for cabin-boats is allowed. Group 3 denotes the sports fishermen. Group 4 represents the aquatic infrastructure accessible to all boat types. Finally, group 5 reflects the sailing opportunities on the large waters of the Biesbosch.
How are these boat categories distributed over the Biesbosch area, in relation to the mentioned zoning regulations? From the total sample (16,197 boats recorded), 86% is found on freely accessible waters which account for 65% of the total shore length in the observed parts of the

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* These factor loadings are derived from Pearson correlation coefficients between variables by applying an optimization procedure. They are scaled between -1 and +1, which has approximately the same meaning as values of correlation coefficients.

Biesbosch. Only 9% of all boats is recorded in creeks with a "no mooring" regime for cabin-boats; these creeks cover 17% of the total shore length. Finally, 3% of all boats is found in creeks with a "no motor" regime, which account for 11% of the total shore length. Almost no boats have been recorded in "no access" creeks.
Table 7.2 shows percentages per boat category breaking the various zoning regulations. The most prominent trespassers are the moored and anchored cabin-boats in the "no mooring" creeks. The percentage of cabin-boats recorded in "no motor" creeks is also high but it is exceeded by that of open motorboats. Also a number of yachts has been recorded in these creeks; they must have come there by motor as sailing in the "no motor" creeks is technically impossible. Yet the overall percentage of boats recorded at places where they should not be, is only 6.6%. This is somewhat higher than figures for other wetland areas (Van der Hoeve *et al.*, 1984) where figures of 1-3 % have been assessed.

Table 7.2. Percentages of boats breaking zoning regulations.

			Percentages in		
		Totals	"No mooring" creeks	"No motor" creeks	"No access" creeks
Cabin-boats	Sailing	1457		4.5	0.1
	Not sailing	9937	7.3	1.6	0.02
Open motorboats	Sailing	623		5.3	0.2
	Not sailing	1395		3.7	0.1
Rowing-boats and canoes	Sailing	305			
	Not sailing	1001			0.3
Yachts	Sailing	286		1.7	
	Not sailing	329	3.3	2.7	0.6
Surfboards	Sailing	229			
	Not sailing	138			0.7

Going ashore is only permitted where recreational facilities are present. Most visitors ashore keep to this regulation indeed; from 7.3% of all anchored and moored boats visitors go ashore at places where this is not permitted.

The distribution of moored and anchored boats with motor is shown in figure 7.3. Boats have been recorded in trajects varying in length from 100 to 500 metres. For each of these trajects the numbers have been standardized to densities per 100 metre shore length. Also shown are most of the mooring facilities in the Biesbosch. These facilities include small marinas, tourist moorings and beaches and simple mooring opportunities along dikes. Most of them are located along free access watercourses. The map suggests that facilities almost always go together with density classes (4) to (6). However, the map also indicates that a large number of trajects belonging to density classes (4) to (6) does **not** have any mooring facilities. The overall pattern of mooring and anchoring is thus only partly determined by the presence of facilities.

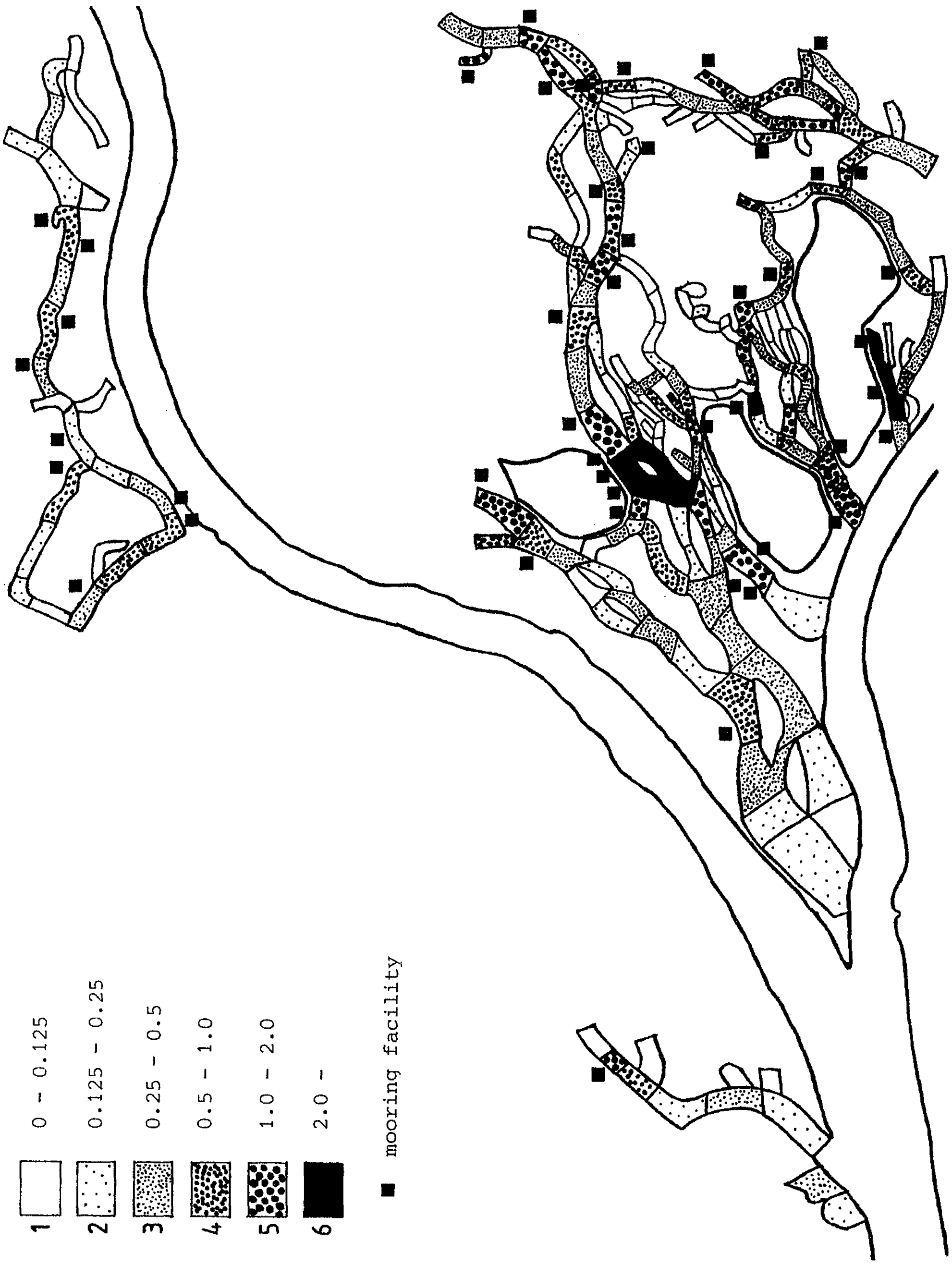


Figure 7.3. Distribution in 1983 of moored and anchored boats with motor. For explanation see text.

An indication of the importance of facilities is shown by table 7.3. Densities of moored boats along dikes and at facilities are much higher than those along reed or willow banks.

Table 7.3. Numbers and densities in trajects with different shore characteristics.

	Reed	Willow	Dike/facility	Elsewhere
Numbers of moored boats	335	219	661	(147)
Densities/100 m	0.4	0.5	1.2	(0.2)

Many watercourses in the Biesbosch tend to be filled up with silt or with eroded bank material in due time. This certainly holds for narrow and shallow creeks (depth at present often less than 0.5 m). But also the deeper (1-4 m) watercourses with free access change in depth, partly by wind-wave erosion of banks and shores, partly by wave erosion caused by boats. At present only some modest dredging is done in the larger watercourses which are used by commercial vessels. Shallow creeks are not dredged anyway; the debate about dredging mainly concerns the narrow watercourses with free access and with the "no mooring regime".

The overall picture emerging from this information is that the pattern of outdoor recreation in the Biesbosch is closely related to the "infrastructure" as composed of sailing regulations, facilities and creek depths. The pattern observed in 1983 can be considered to a considerable extent as the result from changes in this infrastructure from 1970 on. Other governing factors may be the specific experience of natural values (particularly by regular visitors) and also a certain anxiety to get lost (in some parts of the Biesbosch).

Scenario analysis

We already know that the recreational use intensity in the Netherlands and in the Biesbosch has strongly increased (figure 7.1). In order to have some idea about what would happen to the NP in the future if a long-term increase would be the case, we have done a scenario analysis with the aid of a simulation model that consisted of a demographic submodel, two submodels for recreation patterns and an ecological submodel (Braat *et al.*, 1984). Projections have been made for the period **1983-1995**.
We have mainly worked upon three scenarios. The underlying trend for these scenarios is the increase of the population for the Netherlands. The total increase is estimated at 5.7% for the municipalities surrounding the Biesbosch, at 14.6% for those at a distance of 10 to 30 km and at 9.2% for the rest of the country. These differences are caused by different demographic structures and migration percentages (according to data of the provinces of South-Holland and North-Brabant and data from the Central Bureau for Statistics).

A second important feature is the construction of the so-called "Aakvlaai" site. The Aakvlaai, situated in a polder next to the south-east part of the NP, is designed as a Biesbosch dummy, including creeks, reed beds, willows etc. (Oranjewoud, 1981). The purpose of this project is to divert part of the visitors that are heading for the NP. The project has already been "promised" in the seventies as a compensation for sailing opportunities forgone by the construction of several water-supply basins. We have used the capacity prognosis for the "Aakvlaai" site of Oranjewoud (1981). This implies a maximum capacity of 728 boats. We have assumed that 60% of this capacity (i.e. 437 boats) will be used on the **"calculation day"** (1869 boats for the NP on a summer weekend day in 1983), but we have also calculated the impact of this site in the case of only 30% use of the capacity.

One of the **recreation submodels** is a recruitment model that generates projections of total numbers of visiting boats. The model uses the results of the simulations of the demographic submodel. It also uses participation percentages as resulting from the 1983 questionnaire (Van der Linden & Van Eijk, 1984) and it accounts for local changes of regulations and facilities in and around the Biesbosch area.
The **reference scenario** (no policy changes foreseen, no changes in the supply of facilities) results in a total growth of the recreation intensity in the Biesbosch with 13% in 1995, if the Aakvlaai project would not be carried out. In case of a 30% use of the Aakvlaai, the growth will be 6%; with 60% use, recreation intensity in the Biesbosch decreases with 1%. In the latter case, total use intensity (Biesbosch and Aakvlaai together) increases with 23%.
The **recreation scenario** mainly implies an **increase in the number and the size of facilities** (marinas around the NP; more mooring places, extension of beaches and playgrounds, and one or two campings within the Biesbosch area). The increase in recreation intensity is projected to be some 13% larger than in the reference scenario if the Aakvlaai is used for 60% and also in the case of 30% Aakvlaai use.
The **nature scenario** embodies a **restrictive policy** towards visitor numbers. It includes limits to the expansion of marinas, extension of the "no mooring" and the "no motor" regulations, and a deliberate restrictive policy as regards dredging shallowing creeks. Increase in recreation intensity is projected to be 10-11% lower than in the reference scenario.
The projections for these scenario's are shown in figure 7.4. We have added the projection for Biesbosch and Aakvlaai together (in the reference scenario with 60% use of the Aakvlaai), as a projection of the numbers expected in the region as a whole.

The **second recreation submodel** can been called a "filling up" model as it simulates the filling up of 14 sites in the Biesbosch at different total numbers of boats generated by the first recreation submodel. Each site is supposed to have a specific rate of getting crowded; this rate is

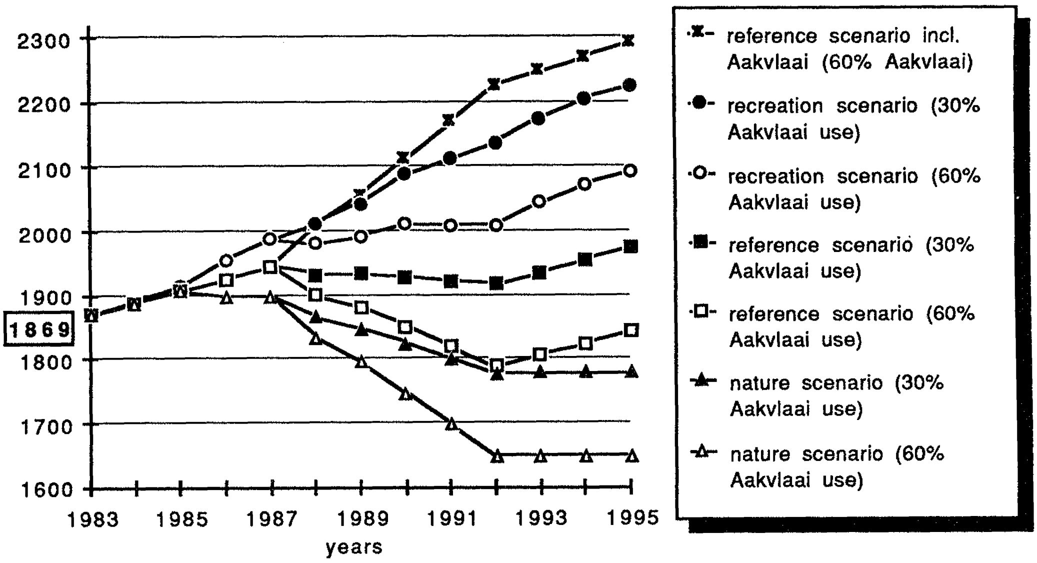


Figure 7.4. Recreational use intensities in different scenarios for the Biesbosch in the period 1983-1995, relative to the **"calculation day" (a summer weekend day in 1983: 1869 boats).**

derived from the field recordings by means of curve-fitting, using a BASIC programme by Spain (1982). The curves fitted are hyperbolic (fast increase first, then slowing down), linear (steady increase) and sigmoid (slow increase first, then a rapid increase which consecutively slows down). All fits are very good (regression coefficients ≥.90).
Except for the realization of the Aakvlaai project, there is no reason to suppose that the *distribution* of relative numbers of visitors over the NP will considerably change over time, unless additional facilities are made or the sailing regulations are changed. The Aakvlaai will exert most influence upon the south-eastern part of the NP but some transition of visitors to this part (as it will be less crowded) from elsewhere seems realistic.
Impacts on numbers by the Aakvlaai, by changes in recreational facilities and by restrictive conservational policies and regulations are incorporated in the model. Figure 7.5A shows the calculated numbers of (moored and anchored) boats per 100 m shore length in the 14 sites in the Biesbosch in 1983 (on the "calculation day"). Figure 7.5B shows percentual differences from this distribution in 1995 for two contrasting scenario's; the reference scenario with 60% Aakvlaai use and the recreation scenario without any use of the Aakvlaai. Sites I-XI are part of the Brabantse Biesbosch, site XII contains part of the Dordtse Biesbosch and site XIII and XIV are part of the Sliedrechtse Biesbosch.

Sites I-IV and XII-XIV are not influenced by the projected Aakvlaai site, while sites VI-X are strongly influenced by it. In the recreation scena-

rio, boat densities are expected to increase strongly in sites II-IV and site X, due to additional recreational facilities; sites IV and X, which are already crowded in 1983, are thus expected to be very crowded in 1995.
In the nature scenario (not shown in fig. 7.5), projections generally do not differ much from those in the reference scenario. In sites II and V less moored boats are expected, and parts of sites IX, XI and XII will become very quiet as no motorized boats will be admitted. However, many visitors of these sites will then go to adjacent sites (or they will moor in the remaining accessible parts of the sites).

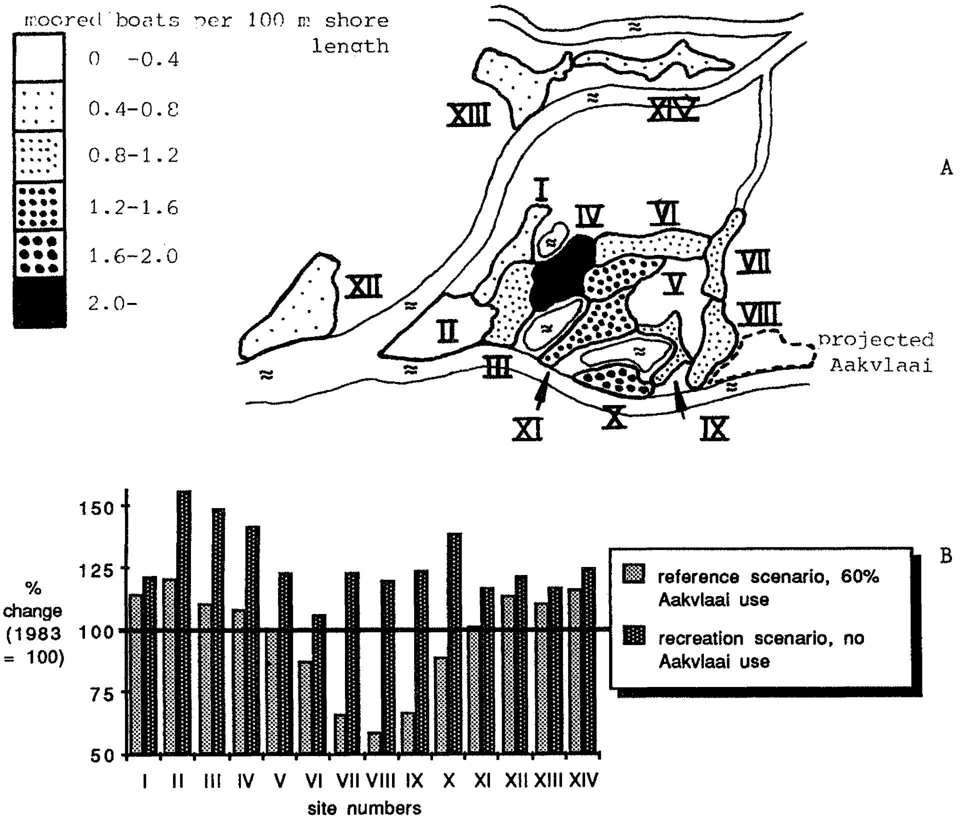


Figure 7.5. Numbers of moored boats per 100 m shore length in 14 sites in 1983(A) and in two contrasting projections for 1995(B).

Conclusions and discussion

A stricter zoning of recreational use in favour of nature conservation seems a fair goal but does not seem to be very effective in the case of the NP Biesbosch, unless very strict regulations would be imposed. Most boats are where they should be, and their owners generally do not behave harmfully for the conservation purposes.
Rather than imposing such proved unpopular restrictions, the above infor-

mation shows that a deliberate increase in modest facilities on locations that are not of outstanding conservational importance would probably attract most of the visitors. Next, intensive information and education about how to behave while visiting this NP may be useful. The two visitor centres, opened since we finished the research and directed towards resource-based recreation, can certainly contribute to the latter (Verkade, 1988).
From our scenario exercise the crucial variable to handle emerges to be the number of mooring places in marinas around the NP. This factor accounts for 70% of the increase in the recreation scenario and for 44% of the decrease in the nature scenario. Particularly in the bird breeding season most visitors come from nearby; therefore a restrictive policy for these marinas could be beneficial for conservation goals.
In comparison to research carried out in the same period as ours (1982) in two other wetland areas, the Nieuwkoopsche Plassen and the Kagerplassen (Van der Hoeve *et al.*, 1984), visitor intensities appear to be relatively low in all seasons. On summer days, some 2800 boats have been counted in Nieuwkoop and some 5600 in Kaag (our "calculation day" being less than 1900 boats). This difference is mainly due to the presence of many yachts in Nieuwkoop and Kaag. Sailing regulations and other zoning measures are reported to function properly, the number of boats breaking the regulations being lower than the comparable number for the Biesbosch (1-3% against 7%).

Perception by visitors of changes in recreational use

As we have seen (figure 7.1), recreational use of the Biesbosch has strongly increased unto 1984. Before 1970 (the closing of the Haringvliet dam and the consecutive disappearance of the tide) only few persons visited the Biesbosch for recreation; they were used to navigation problems (because of the tide) and to the complete absence of any recreational facilities at all. At present, tall and small ships sail the Biesbosch waters, and their crews are familiar with comfort aboard and with facilities in the area.
Nowadays parts of the Biesbosch, particularly the parts with extended facilities (mooring places, playgrounds, viewpoints) are relatively crowded. Other parts are still very quiet. Yet the changes mentioned may have led to a present configuration of different recreational use forms that compete with or even exclude each other.

The issues

As stated in the introduction to this chapter, non-intensive, resource-based recreational use forms are preferred in (Dutch) National Parks. For the "non-intensive" aspect, crowding and congestion, annoyance, damage and littering are relevant issues. As to the "resource-based" aspect, the

presence and abundance of nature and landscape features (ranging from particular plant or animal species to overall scenery) is important.
In relation to these aspects it has been suggested that the original supposedly resource-based visitors have been partly crowded out by facility-based "newcomers". As there is no real substitution for the recreational experience from the Biesbosch, the original habitués would then have to accept the present situation or just forget about visiting the area. Both cases do not really match with the above NP aims.
If the problems stated are real indeed, the manager has to decide whether to accept this situation (including a possible aggravation of the problem if use intensities would continue to increase) or to impose additional regulations to the sailing in the Biesbosch. As both options are not really attractive, a closer look at the problems stated may be useful.

Results of the questionnaire in 1983

In spring and summer of 1983 we have done a questionnaire among the visitors of the Biesbosch (Van der Linden & Van Eijk, 1984). The visitors were asked to fill out a questionnaire form and to send it back to us. From the total of 782 persons asked to cooperate, 695 accepted the form and 397 returned it (51%). Forms were handed out to moored and anchored boats in five sites within the NP which, together, are considered to be both characteristic and relevant to management options although they cannot be representative for the complex NP as a whole. Some characteristics of the sites are given in table 7.4. Site numbers correspond with those in fig. 7.5A (site V being composed of "no motor" creeks in the original sites V, VII and XI).

Table 7.4. Characteristics of questionnaire sites (1983).

Site	use intensity	access	facilities	part of NP	% of returns
IV	high	all	many }		30 %
XI (+IX)	moderate	all	none }	Brabant	37 %
V	very low	no motors	none }		5 %
XIV	moderate	all	few	Sliedrecht	20 %
XII	low	all	few	Dordrecht	7 %

The majority of the respondents age 30-39 years (28%) or 50-64 years (27%). Only 15% has done the primary school only; 19% had university or highschooltraining. 30% of the respondents comes from nearby (less than 10 kilometres), 27% comes from 10-20 km away from the Biesbosch. Most boats (76%) come from marinas in the regio. The majority (55%) stays for a few days and visits the Biesbosch at least once per week (51%).

With regard to **crowding and congestion** perceived, the five questionnaire sites appear to differ considerably. Results are shown in table 7.5. In site IV, 40% holds the opinion that use intensity could still increase, against 0% for site V. In site V, 50% thinks that there are too many boats in the Biesbosch already, against 11-22% for the other sites. From the total scores, 71% apparently does not want more boats in the Biesbosch. Even in the crowded site IV this percentage is 60%. The visitor intensity trends shown in figure 7.1 therefore reflect an actual problem.

Table 7.5. Judgements about use intensities (percentages).

	Total	IV	XI	V	XIV	XII
increase easily possible	9	15	6	0	10	0
small increase possible	20	25	17	0	21	22
keep it at present level	53	41	61	50	57	56
too many boats already	18	19	17	50	11	22
n	374	119	142	16	70	27

Annoyance is mainly perceived from speedboats (by 82%), waterskiing (by 61%), large tourist ships (by 34%) and surfboards (by 20%). These use forms only account for 1-2% of the total number of boats present at a certain moment. Rowing, canoeing, swimming and fishing annoys almost nobody (1-3%). The largest user category, cabin-boats, is an annoyance to 45% of users of other boat types; visitors in rowing-boats and canoes are annoyed most (80% of them).
Table 7.6 shows several Biesbosch features that annoy visitors. Again some differences between sites are clear. Also differences between facility-related and resource-related annoyances are noticeable.

Table 7.6. Annoyance by some features of the Biesbosch (percentages).

	Total	IV	XI	V	XIV	XII
litter, damage	64	67	59	77	71	54
too much noise	27	23	23	71	25	36
too few mooring places	46	47	47	21	54	30
too few beaches	40	54	35	12	38	35
n	393	121	147	19	78	28

As regards the issue of possible **damage** by outdoor recreation to the natural environment of the Biesbosch, most respondents (64%) think that such damage is not demonstrable. Only in site V, the "no motor" creeks, the majority (but only 53%) thinks otherwise.

As regards the **behaviour** of visitors, 73% thinks that this does not at all lead to damage to the natural environment. Only 18% thinks otherwise (9% has no opinion). Again in site V, only 37% holds the "no damage" opinion.

As to the **motives** of visitors to come to the Biesbosch (which are indications for the facility-based or resource-based types of recreation), some interesting contrasts are shown in table 7.7.

Table 7.7. Dominant motives for visiting the Biesbosch (percentages).

	Total	IV	XI	V	XIV	XII
* Landscape	25	20	23	44	36	19
* Silence	18	8	21	17	27	30
* Plants & Animals	3	2	4	17	1	4
TOTALS	46	30	48	78	64	53
* Facilities	15	32	6	6	10	11
* Social contacts	8	9	12	0	1	4
* Near to residence	6	8	6	0	7	0
* Available mooring places in marina	1	1	1	0	3	0
TOTALS	30	50	25	6	21	15
* Opportunities to sail, to fish or to surf	23	20	28	17	14	33
n	377	119	139	18	70	27

Table 7.7 reveals the contrast between sites IV and V (see again table 7.4 for descriptions) with the other sites in intermediate position. Obviously the visitors of site IV differ from most other visitors, particularly from those of site V. These data suggest that for most visitors (except in site IV) the environmental features are far more important than the facilities. This is not the case, because another question in the questionnaire asked for *importance* of the separate motives; the answers indicate that, except for "mooring places in marina", all motives scores were high in all sites except site V.
Factor analysis applied on these data shows that the first three motives (landscape etc.) in table 7.7 establish a first factor (explained variance: 24%), while the next four motives (facilities etc.) establish a second factor (explained variance: 20%). *This result suggests a dichotomy of the recreational use into resource-based and facility-based factors.* Comparable differences have been traced by Brouwer (1986), using a homogeneous scaling method. Information from managers and policy-makers concerned with the NP confirms this interpretation (Visser, 1984).

The question remains whether "veterans" among the Biesbosch visitors are crowded out by newcomers. Table 7.8 shows the percentages of veterans and newcomers for all five questionnaire sites. Site IV has proportionally many newcomers while sites XI and XII are visited by relatively many veterans. These differences are, however, not statistically significant at $\alpha = 0.05$ (χ^2 test), but this is due to sites V and XIV (which are "indifferent").

Table 7.8. Since when do the visitors come to the Biesbosch?

	Total	IV	XI	V	XIV	XII
1) since before 1970	48 %	38 %	54 %	53 %	43 %	56 %
2) after 1975	41 %	49 %	37 %	41 %	40 %	33 %
ratio 1) : 2)	1.2	0.8	1.5	1.3	1.1	1.7
n	393	121	147	19	78	28

Differences between veterans and newcomers may be shown by their respective motives to come to the Biesbosch. From the questionnaire results, only the presence of facilities, notably mooring places and beaches, appeared to show significant results, newcomers being more interested in them. All other motives did not show significant differences. The same holds for the opinions of visitors about features that should uncompromisely be maintained in the NP.

On account of figure 7.1 one might expect some 35% or less of the visitors to be a "newcomer". However, 41% of the respondents to the questionnaire appeared to be so. Although crowding out of veterans cannot be assessed with the present data, the indications for such a process are clear. On account of table 7.8 we may expect the newcomers in sites with many facilities like site IV, while the veterans have moved to (or have stayed in) sites XI and XII.

Conclusions and discussion

As already stated, the trend in overall recreational use intensity is in conflict with the opinion of the far majority (71%) that the Biesbosch is "full". This is in accordance with the findings in table 7.6 that indicate annoyance with regard to the number of mooring places and beaches, and also to the litter and damage. As regards the motives for visiting the Biesbosch, a dichotomy between resource-based and facility-based recreationists can be perceived. This dichotomy is partly parallel to the aspects mentioned above. "Veteran" visitors to the Biesbosch (mainly resource-based) may be crowded out by facility-based newcomers but this cannot be supported statistically.
As we have seen, 18% of the visitors said that there were already too many boats in the Biesbosch. In the wetland areas Nieuwkoopsche plassen and Kagerplassen (Van der Hoeve *et al.*, 1984), 28% and 78%, respectively, said that the area was (too) crowded, while 34% and 19% said that a larger number of boats would be acceptable (Biesbosch: 29%). In these areas most annoyance was said to be caused by speedboats and by surfboards, just like in the Biesbosch. Annoyance by quiet activities (canoeing, rowing, angling) only accounted for 2-6%. Some 40-45% of the respondents asked for increase in the number of mooring places (Biesbosch:

46%). Motives for coming to the areas are difficult to compare because of differences in the questionnaire designs. Yet the importance of nature and landscape is prominent; people coming to Nieuwkoop also mentioned silence or quietness, people coming to Kaag did almost not. Finally, no obvious changes during the last few years (prior to 1982) in selecting these areas for a visit were assessed.
This information points out once more that the Biesbosch is a relatively quiet area, even in comparison with the Nieuwkoopsche Plassen and certainly when compared to the Kagerplassen or other lakes that are used by recreation like the Vinkeveense plassen and the Loosdrechtse plassen (Buwalda, 1984).

"Scars in the landscape": tourist spots

Most of the boats visiting the Biesbosch land at one or more places during the visit. Apart from using prepared, legal landing-stages, many visitors land where they, according to the regulations, should not. **Tourist spots** are defined as locations on shores and banks where the vegetation differs from the expected structure or composition as the probable result of recreational use. More precisely, only locations where such differences exist and where no tourist facilities are present, are called tourist spots. In the research in the Biesbosch in 1983, 119 of such spots all over the NP area have been investigated (Saris *et al.*, 1984). Some of these are very small and hardly recognizable, others are very large.

The issue

The different managers of parts of the Biesbosch (see Chapter 5) all would like the visitors to use shores and banks only where facilities are provided. Their reasons are, however, different. The manager of the water-supply basins wants to avoid the basins being polluted or damaged by recreationists; the manager of willow stands does not appreciate illegal "exploitation" of the timber; the manager of nature protection sites does not accept disturbance of fauna and trampling of the vegetation. The Committee for National Parks considers all such activities not in accordance to the NP status.
All managers must make their choice from a set of alternatives:
- to make the establishment and use of tourist spots totally impossible;
- to avoid establishment and use of these spots only locally;
- to create suitable landing-stages to concentrate landing of boats;
- to induce changes in the intensities of recreational use of the whole NP or parts of it in order to reach acceptable use levels of tourist spots;
- to accept the present situation and hence adapt the original goals.

We shall try to assess the importance of the impacts of actual use intensities on some aspects of the natural environment, in order to facilitate the choice between the mentioned alternatives.

Characteristics of tourist spots

Figure 7.6 shows a general impression of the structure of tourist spots.

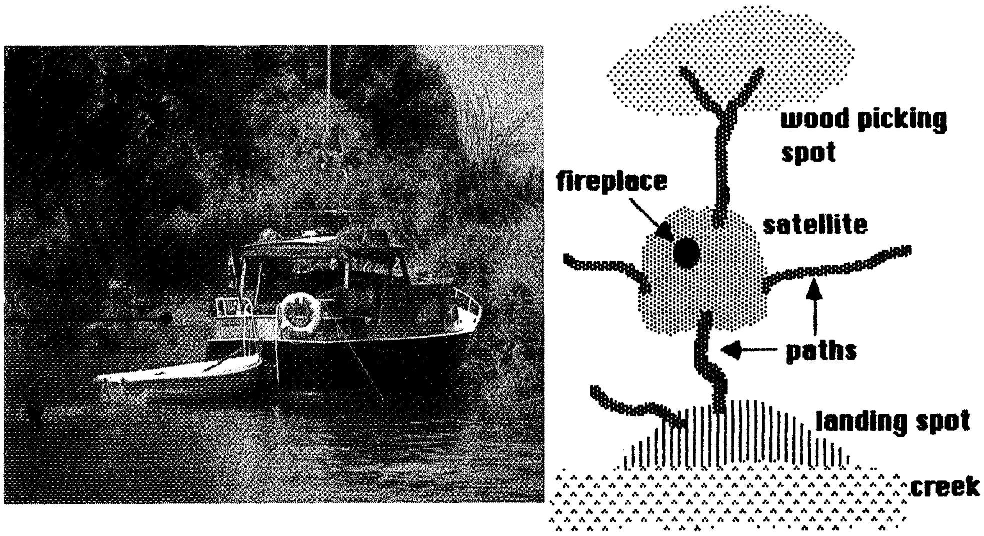


Figure 7.6. Structure of tourist spots (left: photograph; right: scheme).

In 1983 the major part of the vegetation of the Biesbosch NP has been recorded and described (Saris *et al.*, 1984). The above definition of tourist spots implies a value judgment, based on the recordings, about the discrepancy between the expected and the observed vegetation in these sites. Several **alternative** discrepancies have been recorded:

* the vegetation is lower than would be expected, in locations where the composition and the cover of the vegetation do not obviously differ;
* "Indifferent" (ubiquitous) species are present, partly instead of species characteristic for the Biesbosch. Examples are *Poa trivialis, Dactylis glomerata, Glechoma hederacea* and *Plantago major*. In such spots grasses are tall, which suggests that use intensity is low;
* very low vegetation is present, mostly consisting of indifferent species like *Poa annua* and *Plantago major* which are relatively resistant to trampling;
* only a small proportion of the soil is covered by vegetation, mainly *Poa annua* and *Plantago major*;
* part of the vegetation is replaced by imported ornamental species like Indian balsam, tulips, daffodils etc.

Comparable changes have been reported by Liddle & Scorgie (1980). Cole & Marion (1988) mention a floristic dissimilarity of 80% for intensively used sites (40-70 nights per year) and 55% for extensively used sites (3-10 nights/year).

The landing-place of a tourist spot is usually bare or it is partly covered by *Poa annua* or *Dactylis glomerata*. The "satellite" is also usually bare in the case of tourist spots in willow vegetations. It is often covered by grasses in tourist spots located along (polder-) dikes, where the satellite is found on top of the dike. In rough vegetation types (shrubs, reed beds) usually no satellites are present.
Differences in vegetation are not only caused by recreational use. In some cases, wave erosion and trampling or digging by animals (cattle, muskrats) may dominantly explain these differences. Such places are not considered tourist spots, although human activities are also often recorded there.
In most tourist spots, recreational use is also shown by a variety of "landmarks": fireplaces, excrements, garbage, mowed vegetation, digging, damage to fences, damage to trees, paths and mooring-posts. Table 7.9 gives an impression of some of these recreational impacts.

Table 7.9. Impacts of tourist spots (Saris *et al.*, 1984).

Tourist spots:	in rough vegetations	in willow vegetations	on dikes
Number of tourist spots	**19**	**81**	**19**
total number of satellites	2	32	8
total number of fireplaces	6	97	17
Presence of excrements	4	37	9
Presence of garbage	6	25	7
Presence of mowed vegetation	7	22	5
Presence of damage to trees	1	56	6
Average surface (m^2)	121	410	153
Average path length (m)	26	28	12

Stimulus-response relationships

The recorded impacts of tourist spots are self-evident. Thus relating these to observed patterns of recreational use of the Biesbosch area (as described in the Section on zoning) seems a simple matter. However, from a number of correlation analyses only few have produced statistically significant results at $\alpha<0.05$. These are shown in table 7.10.
The second and third SR relationship in table 7.10. refer to 14 sites (see pages 149-151) in the NP. No relations could be established for these response parameters at the detailed level of trajects along water courses of 100-200 metres (the field recording level).

Table 7.10. Stimulus-response relationships for tourist spots (willow vegetations only)

Stimulus parameter	Response parameter	Regression equation	Correlation coefficient	Number of records
Moored boats/100 m*	shore length (m) of spot	y = 6.97x + 9.20	r = .33	54
Moored boats/100 m**	nr. of fire- places/100 m	y = .195x + 0.07	r = .55	11
Moored boats/100 m**	surface of spot to total surface of vegetation***	y = 1.58x + 0.34	r = .65	11

* based on trajects recorded (100-200 m)
** based on sites (14 for the whole of the NP)
*** total shore length of willow vegetation per site x 50 m width

These data suggest that impact parameters like shore length, surface and severe impacts on vegetation like fireplaces reflect the relationship between recreational use and the quality of the resource better than vegetational qualities like species composition or vegetation height can do. Analysis of the latter variables has not produced statistically significant results. Yet the correlation coefficients shown in table 7.10 are not convincing either.

The problems encountered in establishing SR relationships are also illustrated by recordings of transects perpendicular to shores and banks. The following variables appear to be positively correlated ($\alpha<0.05$) with recreational use intensities: surface bare ground, number of open spaces in woodland, length of these open spaces, total species number and percentages cover of *Ranunculus repens, Poa trivialis, Polygonum amphibium* and a number of other species. A negative correlation has been found for *Urtica dioica* which is very abundant in the NP.
These correlations seem promising but they are mainly due to many "zero-zero" recordings (e.g. no boats and no bare ground recorded) on the one hand and a few "extreme" recordings (e.g. many boats and much bare ground) on the other hand. Such a data pattern easily produces significant correlations if the sample size is large enough. Use of such data in establishing SR relationships is therefore very questionable.

This analysis does not disparage the importance of the recorded impacts in the tourist spots. It is, however, very difficult to draw any conclusions about *changes* in the number and the quality of tourist spots as a consequence of changes in recreational use.

Recovery of tourist spots

In 1983, only nine out of 119 cases tourist spots have been recorded to recover from recreational impacts. This recovery implies that the observed vegetation closely resembles the expected one (height, composi-

tion) and that fresh signs of human activity are missing. Recovery is assessed by comparison with data of previous years.
The low number of recovering spots does not allow any detailed conclusion about the recovery rate. Growth rates of most Biesbosch vegetation types, however, are high and one can reasonably assume full recovery within a few years if the spot would really be left alone.
Some recovery also takes place when the tourist spot is not used; most spots are almost only used in weekends from April to September. This may explain the observation that, compared with previous years, some spots appear constant as regards the impact parameters.

Tourist spots and the sailing regulations

Table 7.11 shows how the different tourist spots are distributed over the important categories of the sailing regulations (see page 143).

Table 7.11. Tourist spots and the sailing regulations.

	Tourist spots:			
	in rough vegetations	in willow vegetations	on dikes	recovering sites
Total nrs. of tourist spots	**19**	**81**	**19**	**9**
nrs. in "free access"	18	71	15	5
nrs. in "no mooring" (for cabin-boats)		4	1	4
nrs. in "no motors"		6	2	
nrs. in "no access"				
nrs. elsewhere	1		1	

For explanation of categories in rows and columns see text.

The far majority of the spots (85%) is located along the watercourses with free access. From the whole sample of boats recorded in 1983, 86% was moored in these courses. Only 7% of the spots has been found along "no mooring" watercourses, where 9.6% of the moored boats was recorded. In contrast, 6.3% of the spots are located along creeks not accessible to motorized boats where only 2% of the moored boats was recorded. Finally, the proportionally high number of recovering spots along "no mooring" courses is remarkable.

Changes in relation to the NP status

The present multiple use situation in the Biesbosch is not unanimously considered to meet Dutch standards for National Parks. Conservationist organisations plead further restrictions to recreational use by motorized boats, while water sport organizations claim that they have lost already too many sailing opportunities due to the water-supply basins. The proposal by the Committee for National Parks for a stricter zonation (see

Chapter 5) will undoubtedly influence the existing recreation pattern. The information described in this chapter can help us to assess the effectiveness (in terms of NP considerations) of this proposal.
At the present level of recreational use intensity, some 30% of the tourist spots along watercourses with free access would come under the "no mooring" regulation. As cabin-boats account for 75% of the non-sailing boats counted, and 7% of them breaks the regulations, we may expect a reduction of these tourist spots with (75-7) * 30 = 20%. However, we also may expect these cabin-boats to moor elsewhere (assuming that the area is not full and the visitors still come), thereby increasing the number of tourist spots along the free access watercourses left. The scarce availability of mooring places is already a source of annoyance (see table 7.6); more visitors would get the impression that the Biesbosch is full.

As regards the projections generated by scenario analysis, an indication of the differences between the reference, the recreation and the nature scenario is given in figure 7.7. This figure shows the changes in comparison to 1983 of the surface area of tourist spots in some of the 14 sites used in the scenario analysis (see also table 7.10).

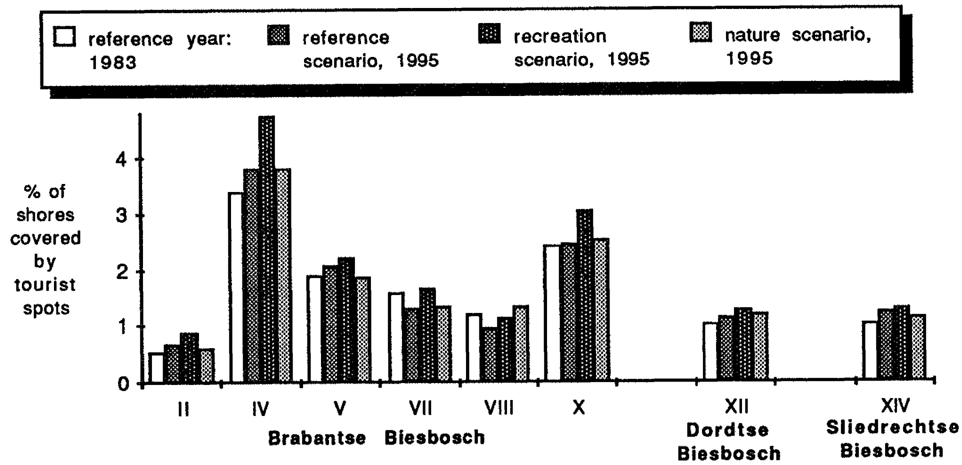


Figure 7.7. Changes in surface area of tourist spots in various sites within the Biesbosch, in comparison with 1983, in three alternative scenarios (assuming 30% use of the Aakvlaai site).

Changes in the reference scenario appear to be less drastic than in the recreation or in the nature scenario. In the reference scenario, surface areas of tourist spots in 1995 vary from 0.7% in site II to 3.8% in site IV. In the recreation scenario, this variation is 0.9% (site II) to 4.7% (site IV); in the nature scenario the variation is 0.6% (site II) to 3.8% (site IV). In sites VII and VIII, the "Aakvlaai-effect" partly leads to reduction of surface areas of tourist spots.

Conclusions

Tourist spots clearly show, together with recreational facilities, the impacts by recreationists on the natural environment of the Biesbosch. SR relationships and recovery rates are difficult to assess. Thus as yet this impact on the Biesbosch as a NP cannot be formulated in terms conducive to scientifically based management. The only measure to be taken on account of the data presented would be to change the sailing regulations in such a way that a large part of the presently freely accessible watercourses would fall under the regime of "no mooring". However, such a change would not be appreciated by the visitors (see the previous Section) and would be more expensive than leaving the sailing regulations as they presently are. Figure 7.7 indicates that the differences (in terms of surfaces covered by tourist spots) between the reference scenario and the nature scenario are mostly small.
In tourist spots, some features (like fireplaces) are not compatible with general NP aims. However, recreational impacts also seem to increase the variety of the habitat structure, thereby enabling more plant species to settle. The decision to enhance such "enrichment" by tourism or by "ecological management" is basically a political one. Such a decision cannot yet be based on the empirical data collected.

Tourism and bird populations

Breeding populations of some bird species are negatively influenced by high recreational use intensities. However, the actual impacts are often hard to assess (Van der Zande, 1984; Kuyk, 1985; Reijnen, 1988). This is mainly caused by the facts that not all bird species are equally sensitive to disturbance and that the selection (by birds) of nesting sites is influenced by a variety of factors, among which many detailed features of the natural environment. The breeding success of a population also depends on a variety of factors. Long-term changes in populations may be influenced by events during the annual migration and during the overwintering period elsewhere.
In the Biesbosch area the variety of breeding species is locally very small, particularly in sites with tourist facilities and a high recreational use intensity. Therefore one might expect the composition of the avifauna (as a possible target in conservational use) to be partly dependent on recreation.

The issue

The managers responsible for conservational use consider the increasing recreational use of the Biesbosch to interfere with various aims as regards the avifauna (Visser, 1984). Among the importants aspects are (see Anon., 1982; Saris & Van der Salm, 1984; Reijnen, 1988):

- some nationally rare species that potentially could breed in the Biesbosch successfully, actually do not (e.g. Little Egret, Little Bittern, Spoonbill, Osprey);*
- some rare species breed in numbers lower than possible (e.g. Purple Heron, Bittern, Garganey, Grey Lag-goose, Spotted Crake, Kingfisher);
- some less common species might decline in numbers by recreational impacts (e.g. Gadwall, Sand Martin, Bluethroat, Savi's Warbler);
- common species characteristic for the habitat might also decline in numbers (e.g. Shoveler, Avocet, Common Tern, Wren, Reed Warbler, Dunnock);
- birds moulting, foraging or overwintering in the area might be disturbed (notably geese and ducks).

With regard to this interference and to the NP status, the managers are faced again with the choice from the alternatives as indicated in the case of the tourist spots. In this Section we shall focus on trying to assess the importance of the impacts of actual recreational use on bird populations.

Stimulus-response relationships

SR relationships can only be assessed if the "responding" species are present. Thus for species like Little Bittern and Spoonbill this cannot be done. However, Spoonbills forage in the Biesbosch area in September and, except for recreational activities, there is no clear reason why they would not breed in the NP. This also holds for the Little Bittern, but this species is reported to decline in the Netherlands generally.
A comparable problem occurs in the case of rare species. If, on a surface area of several thousands of hectares, only 10-20 breeding pairs of a species are present, it is almost impossible to develop SR relationships. As in the previous case, this does not at all imply that the species would not be influenced by recreational use intensities, even low ones. We just cannot prove anything. Only careful experiments or observations in areas where the species is common might render an answer (see also Reijnen, 1988). In the Biesbosch this has been tried for the Kingfisher (Saris & Van der Salm, 1984) as regards the actual foraging behaviour of adults. There appears to be a negative correlation between the number of boats passing by and the number of foraging flights by adults actually carrying food.
Less common and common species (both at the national scale) may be suitable for detecting SR relationships if they are common in the study area. In the Biesbosch research (Saris & Van der Salm, 1984), sixteen locally abundant species have been observed in detail in 20 sites where recreational use has been recorded as well. Correlation analysis applied on the data only reveals very few significant relationships. Both posi-

* For convenience, we have mainly used English names of bird species in this Section. Appendix A contains both English and scientific names.

tive and negative correlations are found, but in all cases the correlation is weak ($r \leq \pm .45$). Stronger positive correlations (up to $r = .60$) are often found between numbers of breeding pairs and general habitat variables, notably creek density and presence, density and height of woodland. These findings agree with results from comparable research in another Dutch wetland area, "Nieuwkoopsche Plassen" (Rodenburg & Ter Steege, 1983).

A possible theoretical explanation (originally proposed in Van der Ploeg *et al.*, 1984) for the lack of significant negative correlations between recreation and bird populations (which are expected to be found in an intensively used area like the Biesbosch) is given in figure 7.8. In the upper left figure (1), the curve denotes an assumed (hyperbolic) relation between habitat complexity and bird abundance. The size of territories for a species constitutes an asymptote (L) as the upper limit to the abundance. The upper right figure (2) indicates an assumed SR relationship between recreation and the bird species. It is comparable (but reciprocal) to curve (3) in fig. 3.3 (Chapter 3) and it suggests that at low recreation intensity levels no SR relationship can be assessed (dotted line traject).

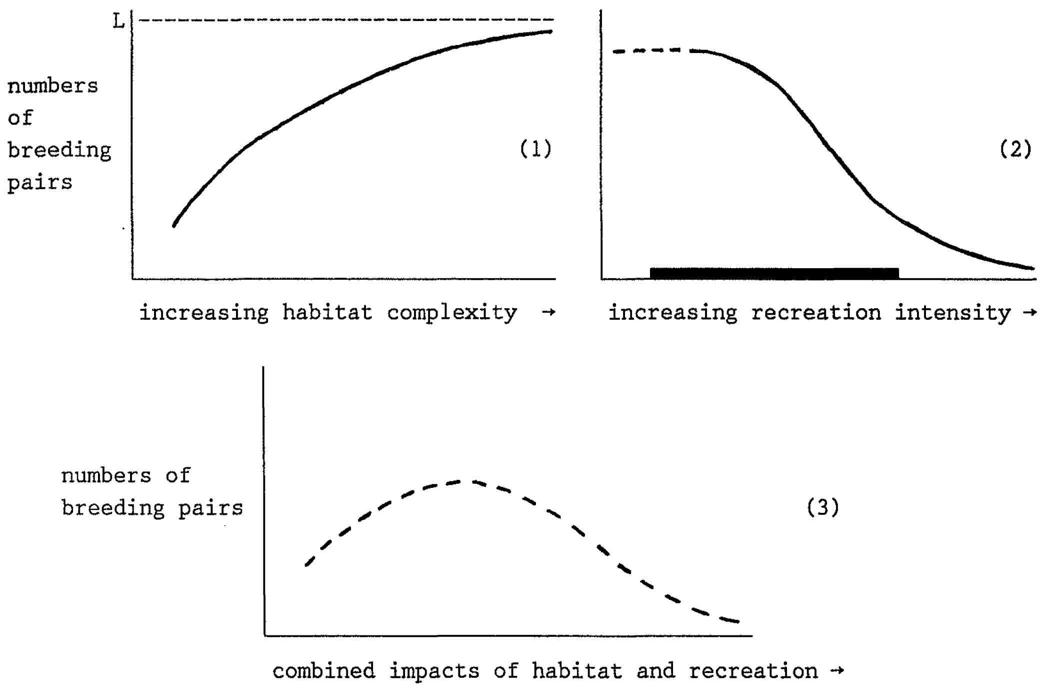


Figure 7.8. Theoretical relationships between habitat complexity (1), recreational use intensity (2), a combination of these stimuli (3) and numbers of breeding pairs of a bird species. The thick part of the horizontal axis in (2) represents the presumed recreational intensity range in the Biesbosch.

The lower figure (3) results from combining the other figures and suggests that, with higher recreational intensity levels, recreational use becomes dominant as the explanatory impact on bird abundance. The shape of this curve is comparable to the one shown in fig. 3.4 (Chapter 3). In the latter, however, the stimulus is considered to act in two different ways (one stimulating the response parameter positively, the other negatively). In fig. 7.8, two completely different stimuli interact.
The thick traject along the horizontal axis of figure (2) suggests that the range of observed recreational use intensities has its maximum somewhere at the declination of curve. This might explain why:
* almost no significant correlations have been found;
* correlations differ in sign;
* *linear* regression has no meaning.

We have tried to explore the above theory by analyzing the Biesbosch data again. Stimulus (i.e. numbers of boats) data have been rearranged into data for total numbers of moored boats and total numbers of sailing boats. From the original 20 sites sampled, one had to be excluded because stimulus data could not be retrieved correctly. The remaining 19 samples were divided into two overlapping sets: one containing 11 relatively "quiet" sites and one containing 10 relatively "crowded" sites (both as regards the moored boats). Both sets therefore contain two sites that are considered intermediate between "quiet" and "crowded".

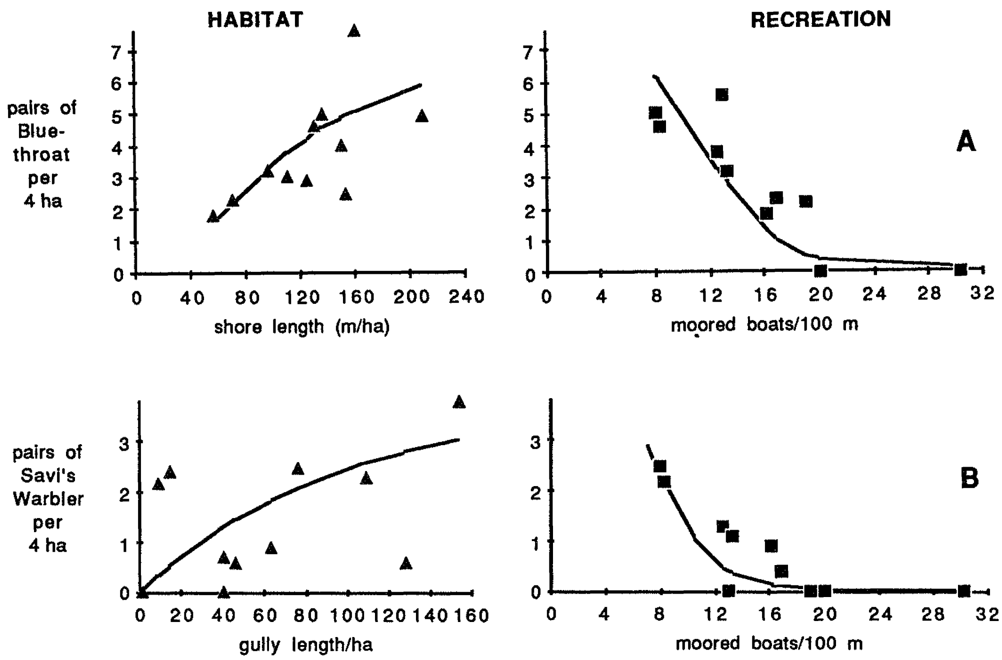


Figure 7.9. Stimulus-response relationships for two breeding bird species in the Biesbosch: Bluethroat (A) and Savi's Warbler (B). For explanation see text.

For both sets, linear as well as non-linear curve-fitting has been done, and the non-linear curves are sigmoid mainly. Figure 7.9 shows the results for Bluethroat and for Savi's Warbler.
Both species are "reed birds", i.e. breeding in areas where Common Reed (*Phragmites communis*) is abundant. Both are also reputedly interesting from a nature conservation point of view (Saris & Van der Salm, 1984). From a range of habitat variables, the shore length of creeks per hectare appears to correlate best with the density of Bluethroat breeding pairs (upper figure, left; r=.65 and p=.03 for linear regression, p=.01 for the fitted sigmoid curve shown). The linear regression from moored boats on Bluethroat breeding pairs is also significant (r=-.86, p=.002) and the best fitting curve is a reversed exponential sigmoid (p=.001).
The correlation between the surface area per hectare of gullies (i.e. small, not navigable creeks, ditches etc.) and the density of Savi's Warbler breeding pairs is not statistically significant (r=.45, p=.17), but the fitted exponential sigmoid is significant (p=.02); correlations with other habitat characteristics show even lower correlation coefficients. The regression from moored boats on breeding pairs is significant (r=-.76, p=.01) and the best fitting curve is a reversed sigmoid (p<.001).

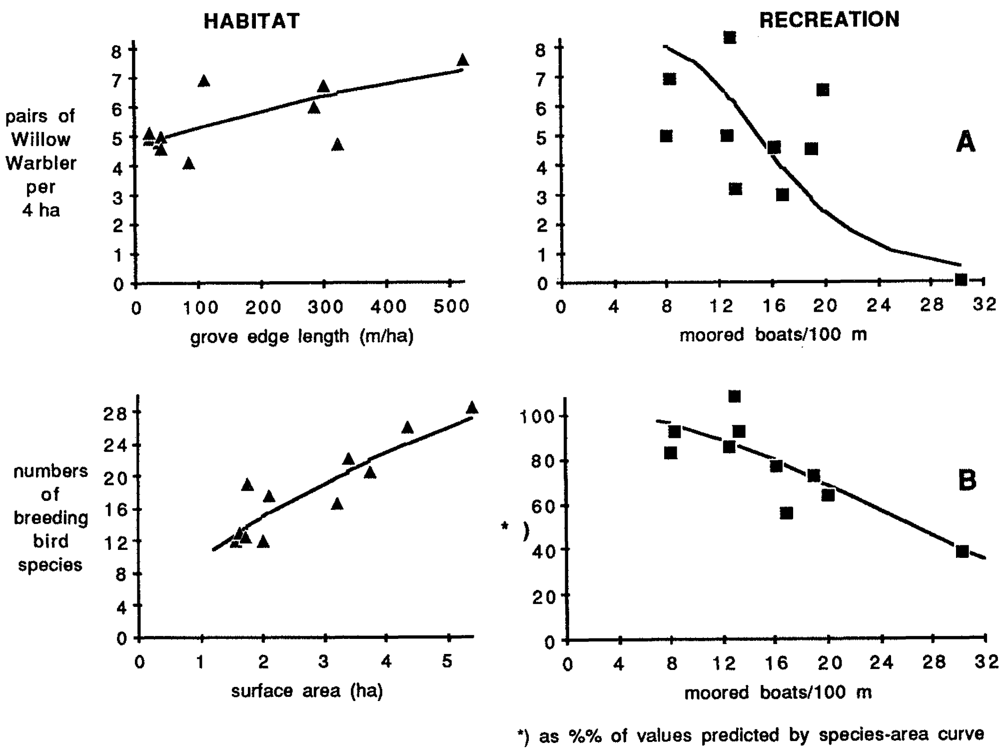


Figure 7.10. Stimulus-response relationships for breeding pairs of the Willow Warbler (A) and for the total number of breeding bird species (B). For explanation see text.

Figure 7.10 shows the results for a "woodland song-bird", the Willow Warbler, and for the total number of species.
The correlation between the habitat variable "grove edge length" (i.e. the edge length of a woodland type with only few shrubs and trees) and the density of Willow Warbler breeding pairs is significant ($r=.68$, $p=.02$) and the best fitting curve is an exponential sigmoid ($p=.01$). The linear regression of moored boats on Willow Warbler breeding pairs is also significant ($r=-.66$, $p=.04$) and the best fitting curve is a reversed exponential sigmoid ($p=.02$).
The number of species does not correlate significantly with any habitat variable but it is strongly correlated with the surface area of the site ($r=.90$, $p<.001$); the best fitting curve is the power function commonly known as species-area curve ($y=8.47 * x \uparrow .65$; $p<.001$). For the regression of moored boats on numbers of species, recorded numbers are expressed as percentages of numbers predicted by the species-area curve. The linear regression is significant ($r=-.82$, $p=.004$) and the best fitting curve is a reversed exponential sigmoid ($p=.005$).
We have also analyzed the data for a number of other breeding bird species that occur in sufficient densities to enable statistical calculations. Some of these show a significant correlation ($p<.05$) with habitat variables: Wren with "grove edge length", and Marsh Warbler, Reed Warbler and Reed Bunting with "shore length". Almost significant correlations ($.05 \leq p \leq .10$) are found for Pheasant with "total woodland edge length", for Garden Warbler with "medium size woodland edge length" and for Chiffchaff with "dry roughs". No correlation has been found for Mallard.
For all these species except Pheasant ($r=.08$), negative correlations with "moored boats" have been found but these are not statistically significant (r varying from -.16 to -.31). None of the species analyzed correlates significantly with numbers of sailing boats or total numbers of boats.

As regards the projections for breeding birds by scenario analysis, we have analyzed the data for Bluethroat, Savi's Warbler and the total numbers of species. In the case of 30% use of the Aakvlaai project, these three "response" variables would decrease 0-5% in all scenarios except the reference scenario where all variables would slightly increase. Only if the Aakvlaai project would not be carried out and the recreation scenarios would become reality, the increase in recreational intensity would be rather substantial (6-24% increase in the different sites). The corresponding average decrease (if we may believe the above SR relationships) would be some 20% for the species numbers and some 30% for Bluethroat and Savi's Warbler.
In the nature scenario, various watercourses would come under the "no mooring" regime. This would reduce the number of moored boats to almost zero and the number of breeding birds might increase. This increase would, however, be limited by habitat characteristics and by the territory size for each species; if the habitat variables in fig. 7.9 are indeed

limiting factors, both Bluethroat and Savi's Warbler would only marginally increase along the watercourses that would come under the "no mooring" regime.

Finally, the 1983 research project has also included a detailed study (Saris & Van der Salm, 1984) of the density, the breeding success and the behaviour of Great Crested Grebes. No significant SR relationships between recreational intensities and the density and the breeding success have been found. As regards behavioural aspects, 15 pairs of Grebes have been frequently observed during weekends and holidays between 22 May and 26 June 1983. The time spent on non-breeding activities significantly increases with an increase in the number of passing boats ($r=.68$, $p<.005$). The same holds for the number of changes in behaviour per observation hour ($r=.65$, $p<.005$) and the number of actions that are apparently "disturbed" (e.g. alarming, leaving the nest after covering it, flying away; $r=.73$, $p<.005$).

Conclusions and discussion

At several places in the Biesbosch and for several bird species disturbance by recreation has been recorded. The behaviour of Kingfishers and Great Crested Grebes changes with increasing recreation intensity; densities of Bluethroats, Savi's Warblers and Willow Warblers decrease, as does the total number of species. Densities are probably determined by certain habitat characteristics and by territory size (both being different for different species), and are only influenced by relatively high recreational intensities. If the stimulus-response relationships found are realistic (which cannot been proven by this explorative type of research), a substantial increase in recreational intensity would probably induce a clear reduction of the numbers of breeding pairs.
The habitat characteristics that have been measured provide no precise details about vegetation structure. The regressions from habitat variables on bird densities may thus be only part of the reality. This also holds for stimulus measurements. Although the "number of moored boats" seems appropriate for establishing significant SR relationships, the actual stimulus may be much more complex. However, the data do not allow a more detailed analysis. Also the non-correlations with "sailing boats" do not at all prove that such activities would have no impacts. Finally, the research has not been designed to make a clear difference between habitat impacts and recreational impacts as is suggested in fig. 7.9 and 7.10. Explanatory research is needed to test the theory proposed.

Research on impacts on breeding birds by water-based recreation is reputedly difficult, on account of the above arguments. In the Netherlands, only in the case of recreational impacts on meadow-birds (boats mooring at pastures) significant SR relationships have been demonstrated (Vos

et al., 1984). In most other cases (e.g. Van Schaik, 1985) no significant relationships have been found. Positive correlations between recreation and breeding bird densities have also been published (e.g. Van der Hoeve *et al.*, 1984; Saris & van der Salm, 1984). At least in the case of the Nieuwkoopsche Plassen (Van der Hoeve *et al.*, 1984) reanalysis of the data by us has revealed a probable joint regression from certain habitat variables on both birds and tourists.
Reijnen (1988) has strongly criticized the research design and data analysis as reported in Saris & Van der Salm (1984). The majority of his remarks on the statistical analysis of the data is acknowledged, although we cannot understand his criticism on the processing of stimuli data, as he does not indicate how this should be done properly while authoritatively reviewing stimulus-reponse relationships between recreation and birds. As to the design of the research, the above re-analysis suggests that habitat factors have played a more important role than recreational impacts (as has been the case in the research in the Nieuwkoopsche Plassen; Van der Hoeve *et al.*, 1984). The research team actually expected a dominance of recreational impacts in the Biesbosch, which would have overruled other factors. The research design has perfectly shown that truth can be different from expectation.

Water-supply, recreation and nature conservation

At present three water-supply basins in the Biesbosch have been constructed. These basins mainly serve the drinking water-supply for the Rotterdam agglomeration. Their production capacity is $250*10^6$ m^3 per year. The actual production is ca $125*10^6$ m^3 per year; the maximum capacity is considered to be sufficient up to 2010 (Anon., 1983). Figure 5.5 (page 87) shows the location of these three basins and also the reservation for a fourth one, located at the east side of the Brabantse Biesbosch.

The issue

The Committee for the National Parks has advised to exclude these four sites from the NP. For the existing three basins this seems reasonable. The following impacts have been forecasted in case the fourth basin would be constructed (Anon., 1982):

* Loss of ca 60 ha with saltings, reed beds and holms, and also loss of 2800 m length of creeks that are important for conservational use;
* Loss of the polder area for foraging geese, ducks and birds of prey;
* Loss of part of the large-scaled landscape and loss of a creek and several reed and willow areas important for recreational use;
* Change in the landscape by a high dike around the basin;
* Loss of several features that are interesting from a historical point of view (ancient buildings, remnants of dike breaks).

The issues for the NP managers are:

1) Should the present polders where the fourth basin is to be located, be part of the NP?
2) How should a possible claim on construction of the fourth basin be answered?
3) How could the basins, being located inside the NP area but not formally being part of it, be compatible as much as possible with other use forms like recreation and nature conservation?

We shall briefly analyze these issues from three viewpoints: the demands and constraints for water consumption, for outdoor recreation and for conservational use.

Demands and constraints

The water-supply company acknowledges that the capacity of the present three basins will be sufficient until beyond 2000, on the basis of the present supply prognosis (see also Anon., 1983). However, if this prognosis would appear to be too low or if the quality of the water used (from the river Meuse) deteriorates, a larger capacity will be needed to ensure a constant supply to the consumers. This viewpoint is shared by the National Government and by the Advisory Council for physical planning; therefore the reservation is included in the "structuurschema" for the supply of drinking-water and water for industrial purposes (Anon., 1986b).
However, the integral research project on water-supply in South-Holland (Anon., 1983) has led to the conclusion that the capacity of the present three basins could be increased to $300*10^6$ m^3 per year. Most of the capacity is presently used for supply to the Rotterdam region. It would also be possible to project basins in other regions of the province of South-Holland, instead of in the Biesbosch region.

From the viewpoint of the visitors to the Biesbosch area, parts of the site for the fourth basin and its surroundings are used as an integral part of the Biesbosch. Construction of the basin would again reduce the opportunities for sailing and mooring, although it would not close off important throughways. The visual amenity of the NP landscape as a whole would be affected, and also the details of the Biesbosch polder landscape would change (present small dikes of polders being replaced by a huge dike for the basin). As we have seen (table 7.7), the landscape is the most dominant motive for visitors to come to the Biesbosch. The response to our questionnaire (Van der Linden & Van Eijk, 1984) also indicates that 52% wants the present landscape of the Biesbosch to be preserved. Defacement of the landscape (including the high dikes around the basins) is a source of annoyance to 42% of the respondents.
The construction of the fourth basin would imply the loss of a number of simple mooring places (in a natural landscape) that are at present frequently used by resource-based visitors (many of them coming to the Biesbosch since long ago; Anon., 1978b). As in the case of the other basins,

new facilities (including playgrounds etc.) would probably be created along the edge of the fourth basin. This would increase the number of facility-based visitors. The ecological impacts of these changes could be a further extension of the number of "tourist spots" and an increased disturbance of breeding bird species. Also the annoyance to "veteran" visitors may be increased.

From the conservational point of view, 20% of the extent of the fourth basin (308 ha) is valuable. The polders within the projected location are in agricultural use and most of their surface has only little conservational interest. The Committee for National Parks (Anon., 1985a) states that these agricultural grounds should not be part of the NP but might become part if their conservational interest (notably as regards the avifauna) would increase.
Changes in recreational use as a result of the construction of the fourth basin may also affect conservational interest. Replacement of the polders by a basin would reduce foraging opportunities for wildfowl, notably geese, ducks and birds of prey (Anon., 1982).

Conclusions

As to the issues stated, the following conclusions can be drawn.
1) The location of the fourth basin as a whole should be included in the NP. However, the polders presently in agricultural use should be temporarily excluded; for these polders, creation of more natural habitat should be enhanced. Inclusion in the NP can be argued by the fact that the site is an integral part of the Biesbosch area and is important for both recreational and conservational use, be it modestly.
2) A claim on construction of the fourth basin can be answered by comparing actual trends in water demand with the maximum capacity. Possibilities to increase the supply capacity may be explored. In case the demand would tend to exceed supply, water-supply in the province of South-Holland as a whole should be analyzed again integrally (cf. Anon., 1983).
3) Edges of basins should not be designed as facilities for visitors, except for simple mooring facilities that can be integrated in the Biesbosch landscape. In case the construction of the fourth basin is necessary, the extent of it should be discussed again. It would certainly be possible to restrict the basin to one or two polders, thereby reducing the impact on both recreational and conservational use.

Evaluation of multiple use in the Biesbosch

In the previous Sections a selection of interactions between outdoor recreation, nature conservation and water-supply has been discussed. The general tendency of our conclusions is that there is a delicate balance

between these use forms. Substantial increase of any of these use forms would clearly affect the other ones.
For completeness, we have to keep in mind that a number of use forms has not been analyzed in this chapter. Some of these also have impacts on recreational and conservational use of the Biesbosch area. The following multiple use interactions deserve mentioning.

1) *Water management* includes the water outlet regime of the Haringvliet sluices. This regime tends to be unpredictable over time and incidentally a drastic decrease of water levels in the Biesbosch occurs. This causes death of organisms on shores and banks and also results into casualties with tourist boats.
2) Use of the main watercourses through and around the Biesbosch area for *commercial transport* induces erosion of banks and shores and constitutes risks for tourist boats, particularly the non-motorized ones. Regulation of the river Beneden Merwede in favour of transport use would include removal of river dunes in the NP that are unique and irreplaceable.
3) *Exploitational use* of polders tends to change from use as pastures into use as arable land. Such changes reduce the conservational interests and the possibilities for habitat creation. Hunting and poaching are not compatible with NP aims and also disturb recreationists.
4) *Pollution* (i.e. use of the Biesbosch as a waste receiving substrate) constitutes a growing problem for all use forms. Air pollution (e.g. by the Amer electricity plant, but also by industry and traffic around the Biesbosch) may affect susceptible plant species and may change the quality of the water in the three water-supply basins. Water and sediments have been and are locally polluted by water from the river Rhine (see Van der Ploeg *et al.*, 1989). This may affect susceptible animal species (e.g. Cormorant, Tufted Duck) and also implies risks to visitors of the Biesbosch.

Analysis and evaluation of all these interacting use forms within one multiple use framework is not the scope of this book (and would also hardly be possible because of lack of information). We shall confine the following evaluation to the three use forms selected for this chapter.

Summary of findings

Table 7.11 summarizes the various interactions between use forms as assessed in this chapter.
At present, water-supply is not influenced by the other use forms, but it locally excludes recreation and conservation. For recreation this is compensated by the recreational facilities at the edges of the water basins; for conservational use there is no compensation. Conservation excludes recreation locally, and is only competed modestly by it (at least in the present situation). The overall picture emerging from these

Table 7.11. Multiple use interactions in the Biesbosch.

IMPACTS ON →	Conservation	Recreation	Water-supply
ACTIVITIES: Zoning for conservation	X	LE	O
Recreation			
* tourist spots	(-)	X	O
* distribution	(-)	X	O
Water-supply	LE, L-	LE, L+	X

O = indifference; + = cooperation; - = competition; E = exclusion
L = local; () = modest.

statements is a relative stability in terms of multiple use: although water-supply is dominating, it does not exclude the other use forms from the larger part of the area, and the other use forms are in conflict only locally.
We have found no reason to suppose that this present multiple use configuration would not be sustainable over time. If no changes in the configuration (including intensities and area demand) would occur in future, all use forms can continue to use the resources of the area without apparent depletion of resource stocks. Yet none of the use forms can maximally reach aims and objectives at present, which, in itself, is an unstable situation. The present claims for conservation, recreation and water-supply basins could easily disturb the relative stability, although this does not necessarily imply a reduced sustainability.

Which actions needed?

We have not assessed important indications for the necessity to change the whole of management actions being taken at present. Conservational use is being enhanced, recreational use is not stimulated and only modestly excluded and water-supply basins do not yet require more space. We have discussed several possible management actions as regards their consequences for multiple use. Extension of zoning regulations in favour of conservational use does not seem necessary and the visitors would certainly react negatively on such an extension. One can really wonder if the conservational benefits from such management actions would balance the social and also financial (e.g. in terms of increased patrolling) costs. Rather we would propose to continue the present situation and to monitor both conservational and recreational use in order to assess and to evaluate future changes. On the other hand, selective dredging of watercourses in sites where the visitors should go (thereby changing the

overall distribution of visitors), may reduce visitors pressure in other sites.
As regards recreational use, two important actions beyond the power of the manager have to be taken. First, a restrictive policy for extensions of the marinas in the region is necessary, as this can regulate total recreational use of the Biesbosch. Second, construction of the Aakvlaai site is essential to divert a number of visitors from the area. If these actions are not taken in the near future, a substantial increase of recreational activities will affect conservational use.
The number and the qualities of recreational facilities within the area should not change. It would be worth while to monitor future use of the Aakvlaai site because creation of comparable facilities along the edges of the area might again divert a considerable number of visitors.
As regards water-supply, the manager should object to a fourth basin. Within the area, edges of basins may be used for upgrading natural values and also for resource-based recreation.

In a long-term perspective, recreational and water-supply will increase which again may cause instability of the multiple use configuration. In that case, further recreational development of watercourses in the vicinity of the Biesbosch must be considered. As regards water-supply, reservoirs elsewhere in the regions must be reconsidered before deciding to construct the fourth basin. In all cases, upgrading of natural values should be continued as this can also increase the satisfaction of many resource-based visitors.

Constraints

As in the case of the NHDR, finances may become a problem in due time. Particularly if recreational use would become more restricted than at present, authorities might reconsider the budget. Conservational efforts may be constrained by short-term political aims for water-supply and recreation. This is the more awkward because visitor pressure and water demand partly depend on human population size and are therefore not very "elastic".
One way to overcome financial constraints would be to introduce entrance fees. This seems difficult for an open access area like the Biesbosch, but also in areas like the NHDR or the areas governed by nature conservation organisations visitors can usually get no tickets at entrances but have to obtain them elsewhere. The main problem, however, is the fact that National Parks should have free access.
As the area has already been denominated as a National Park, most of the constraints for the establishment of that *status quo* have already been removed or can be removed in due time. However, we expect that some problems may arise when the present recreational facilities have to be changed or even removed (as a consequence of the exclusion of relatively "intensive" recreation from NP's).

Gaps in available knowledge

As in the case of the NHDR, several gaps in the available knowledge refer to the lack of time series by which trends can made be visible. The patterns of recreation are only generally known and for parts of the area they are even unknown. A programme of periodic censuses (with an emphasis on **frequencies of use** rather than on absolute numbers, cf. Chapter 6) would be useful. Impacts on vegetations (tourist spots) and on breeding, migrating and overwintering birds should also be monitored, by means of a few indicator variables (soil properties, plant and bird species).

The examples given in this chapter show that the available knowledge on SR relationships and particularly on recovery is largely insufficient. As in the case of the NHDR, we have doubts about the usefulness of such information for the manager. As the effectiveness and the acceptation of management actions seem to be the most prominent signals to the manager, we again advocate greater attention for integrated management-response relationships. Monitoring use patterns and impact patterns as a result of management actions can substantially contribute to deliberate management decisions. Again we have not applied the simple IMR simulation model from Chapter 4 to the Biesbosch issues. At present, the data basis for total visitor numbers, visitor distribution and ecological impact patterns is insufficient. Yet we are convinced that such a model type can be useful as a management tool.

8. CONCLUSION

The previous chapters, dealing with multiple use issues in the dune area "North Holland Dune Reserve" and in the wetland area "Biesbosch", contain a large number of examples of use and resource interactions. Referring to the first page of Chapter 1, we can safely conclude that, although use interactions certainly create problems in these areas, the managers are not left to despair. Rather we conclude (at least for these areas) that the general way of coping with multiple use does not apparently lead to threats to the sustainability of that use, be it that details of the management need adjustments.

We do not think that these conclusions make this book useless. We have deliberately chosen examples that have proven to be manageable (instead of selecting examples that just show sheer disaster), in order to detect insights and knowledge useful in decision-making on multiple use. By introducing considerations about multiple use, about capacities and about management, and by checking these considerations against real-world processes, we have intended to increase the body of knowledge (or in other terms, to advance management science) available to managers of any multiple use area to state objectives and to attain them.

This final chapter reviews the conclusions of the previous ones, in an attempt to link the (partly theoretical) concepts and considerations from Chapters 2, 3 and 4 to the real-world information from Chapters 5, 6 and 7. In doing this, we also try to answer the questions about management of multiple use areas as stated in Chapters 1 and 5.

Multiple use of resources

In the cases we have analyzed, the multiple use configuration present has not revealed serious competition or exclusion. This is undoubtedly the result of management actions in past and present. Both recreational demand and water-supply demand are such that, without management, conservational use would almost have been excluded in practice. Therefore the multiple use configuration is only a stable one as long as management actions are effectively directed towards maintaining a certain balance between the competing use forms.

Complex use interactions

Yet both situations analyzed show that most mutual interactions are more complicated than can be expressed by the simple terms of exclusion, competition etc. All use forms cooperate or are indifferent to a certain extent, and only in cases where one particular use form is predominant, competition or exclusion occurs; in that case, partial exclusion is often enhanced by management actions, in order to avoid conflicts. Therefore we conclude that in such situations multiple use configurations can certainly be stable, provided that the resource itself is not depleted (see below).

The above conclusions also hold for interactions between different forms of "recreational" use. Particularly in the case of the Biesbosch, competition between intensive, facility-based recreation and extensive, resource-based recreation or wildlife interest have induced notable changes of the total recreational use pattern. This has not been observed in the case of the NHDR. In the Biesbosch a new balance has been attained where intensive recreation has partly excluded extensive recreation without excluding it completely. Here again the role of management actions has been shown to be decisive, in relation to the term within which changes in use occur or are induced.

Perception of multiple use

In the NHDR we have observed that a far majority of users accepts the present multiple use configuration. In the case of the Biesbosch, acceptance has been observed to be much less. This difference may be explained by the "urgency" of conflicts as a result of changes in multiple use. In the NHDR, all use forms have got their place in different parts of the area in the long run; only locally competing use forms strive for using the same site (e.g. the observations in the site Egmond). In the Biesbosch, changes in use have occurred relatively recent (since 1970) and "new" use forms, water-supply and intensive recreation, have required a considerable portion of the total surface area.

In both cases, regulation by management actions in favour of maintaining the multiple use configuration does not clearly evoke opposition, although in the Biesbosch case further regulations for recreational use seem hardly acceptable. We have no data available to explain this relatively tolerant attitude, but we presume that many users of the areas are well-informed and realize that increasing use would disturb the present balance between use forms.

Signals from authorities, lobbies, owners etc. differ as regards their perception of multiple use. Generally, the nature conservation lobby shows concern as regards almost all use forms except conservational use. In view of the above this concern can certainly be understood. Most parties, however, seem to be rather content with the present situation, although they sometimes claim more room or more facilities. Also the authorities have not shown such anxiety with present multiple use configurations that they have decided to impose stricter regulations.

Is there an optimum for multiple use?

The balances between use forms in the case studies do not imply that in both areas the use of the natural resources is optimal in terms of maximization of utility derived from use (regardless whether this is "over time" or only in respect of present use). Water-supply and (in the NHDR case) sea defence do almost not suffer from any restriction because of multiple use and hence these use forms are probably optimally satisfied. This certainly does not hold for conservational use and for the various recreational use forms. Each of these use forms is constrained, either by other use forms or by management regulations. We do not know how these use forms would expand if these constraints would be absent. But, even more important, we do not know whether such changes in the multiple use configuration would increase or decrease the total contribution of the area to the welfare of the region or even the nation. The only conclusion to be drawn here is that apparently no user positions are seriously injured by the present situation.
Each natural resource area may have a specific multiple use configuration which is optimal from a general welfare point of view. However, if this is not assessed (we did not attempt to do so, and we have doubts about the realism of such assessments; see Chapter 2), the optimum configuration can only be approximated by management actions that are based on compromises between users or their representatives, as they know best what they stand for. Such an "optimum" basically means that all parties agree and therefore must be satisfied at least partially. However, it is no indication for maximization of utility.
The above may hold for multiple use configurations without predominant use forms, but it does not hold in cases where one use form is dominant or where a new use form is proposed, particularly if such dominant or new use forms regard the production of marketable goods. Krutilla & Fisher (1975) have convincingly shown that even in such cases the benefits from recreational and conservational use may exceed "productive" benefits from marketable goods. However, that analysis only applies to situations in large countries where "semi-tangible" benefits, e.g. revealed in travel costs made to visit a specific area, are considerable. In the Netherlands, such benefits seem much harder to find but it would be useful to conduct some case studies on this topic.

Resource capacities

The multiple use configuration influences the resource capacities and *vice versa*. Both case studies have shown that the various use forms have very different impacts on parts of the resource ecosystems. Yet the systems as a whole are, to our knowledge, not affected by multiple use in the sense that they are gradually deteriorating, i.e. the resources are not being depleted (in the past this has certainly been the case in the NHDR as regards groundwater extraction). In both chapters we have therefore concluded that the present multiple use configuration seems sustainable. However, we have no information about sustainability in case of changes in the multiple use configuration, for example increasing demands through time as a result of human population growth or shifts in preferences. Can we obtain such information by reviewing the conclusions about capacities and the underlying SR relationships and recovery rates (Chapter 3) in relation to the results of the case studies?

SR relationships

Although the examples of SR relationships as regards recreational trampling provide valuable information about these use impacts, they are hardly comparable to the real-world impacts described for the NHDR and for the Biesbosch. The most important information to be obtained from such SR relationships seems to be the relative vulnerabilities of different resource ecosystem components for such impacts. Such information can be used in the case of changes in multiple use, notably increase of intensive recreational use forms (assuming that these will cause more impacts by trampling and comparable activities).
In the case studies, differences in performance of ecosystem components (e.g. presence, abundance or volume of plant or animal species) have been related to differences in recreational use intensity. In a number of cases significant relations have been assessed. By comparing performance levels of these components to corresponding levels in SR relationships we may obtain information about the seriousness of the real-world impacts. We may also get some idea about how much the recreational use intensity should be reduced in order to reach acceptable performance levels (assuming that "acceptable" can be defined). However, this cannot be precise information as use patterns are often difficult to predict (in contrast to a self-induced trampling regime); regulation of total use may therefore result into unpredictable levels of visitor trampling.

Recovery

Information about recovery rates is very useful as it enables us to predict whether a resource component will be able to recover at all, and if so, how much time this process will take. Although we have only monitored few recovery processes in the case studies (Chapter 6: Sections on "Zoning", on "Dewberry picking" and on "Horse trails" in the NHDR), these results are certainly comparable to the recovery examples shown in Chapter 3. From the totality of data presented we draw the conclusion that

many ecosystem components in the dune area are able to tolerate stress from use insofar that they rapidly recover after that stress has been removed. Only in case of very high use intensities or impacts that are devastating (horse-riding), recovery takes a long time and some components do not recover at all.
We therefore advocate an increase in the number of studies on aspects of recovery. We are well aware of the fact that such studies may take a long time. However, if we do not assess recovery rates, we will never be able to answer this part of the the sustainability question.

Resulting capacities

Vulnerability towards impacts (as revealed in SR relationships) and regeneration (or colonization) power (as revealed in recovery rates) constitute capacities of different ecosystem components for recreational use forms. Simulation models like the simple ones shown in Chapters 3 and 4 may be used to integrate the different constituents into a picture of the capacity of a component. These models certainly have no explanatory but only explorative value: they can help the manager to identify capacities and to select indicators for ecosystem performance on behalf of these capacities. Adequate explanatory modelling of natural processes and of the precise impacts from human use on these would require much more knowledge about ecosystem components and processes than we have presented in this book. Such models are valuable for scientific purposes but they are too complicated (and therefore too costly) to be readily usable in a management context.
We have not drawn conclusions about the capacities for multiple use in general of the resource ecosystems as a whole in the NHDR and in the Biesbosch. Although we have collected data about a large number of ecosystem aspects in both cases, the interpretation of these data in terms of stimulus-response relationships has been impossible in many cases. As to the biotic ecosystem components, this is largely due to the fact that many species are not abundant, while their absence cannot be unambiguously ascribed to one or several use form intensities. Hence we consider a "system capacity" for any use form to be a semantic concept that can only be operationalized for a limited number of ecosystem components. Only in case of severe stress, inducing large-scale erosion and comparable impacts, it is clear that an ecosystem cannot resist that stress. In such cases, however, discussions about optimum configurations of multiple use are redundant.
Finally we emphasize that local disturbance of an ecosystem must be viewed in relation to the ecosystem as a whole. Our observations on recreational impacts (particularly as regards illegal paths in the NHDR and tourist spots in the Biesbosch) show that performances of species may be only locally affected, without threatening the performances of those species within the total surface of the ecosystem.

Management

The above concluding statements often include assumptions about management actions. Indeed this book has been predominantly about those actions: when is action needed, what form should the action take, is it acceptable to users and policy-makers and what is its effectiveness in terms of changes in use intensity, resource performance and costs?
We have reviewed a number of management actions in Chapter 6 and 7 and we have concluded that most of these actions have been useful, have been accepted and have been effective (although we have not been able to compare alternative actions in terms of cost-effectiveness). In this Section we shall try to relate these observations to the considerations of Chapter 4.

When is action needed?

The answer to this question strongly depends on policy aims and management objectives. In both cases studied, the manager has decided to introduce regulations as a consequence of changing (multiple) use *and* resource characteristics which did not fit to aims and objectives. According to our observations, most of the regulations have not been necessitated by imminent depletion of the resource but they have merely anticipated that process (in other words: some time before the resource ecosystems might show apparent signs of increasing stress, the managers have decided to impose regulations upon use). We therefore conclude that the manager is often ready to take action based on his taxation of the **possible** impacts of changes in multiple use on "his" area; this action is not necessarily based on solid observations of resource response to use.
In Chapter 4 we have introduced Integrated Management-Response (IMR) relationships as a tool for assessing effectiveness of management actions. Such IMR relationships may also be useful in comparing signals from monitoring use and resource indicators with use and resource performance levels as stated by aims and objectives. The simple simulation model shown in Chapter 4 may well act as such and may indicate to the manager when action is to be taken.
Yet such models for IMR relationships only regard the processes within the area. Management action should also be taken when signals from society are received that a certain multiple use configuration is not or hardly acceptable. The case of the Biesbosch is a good example of such a situation, conservational use being sandwiched between recreational and water-supply use.

What form the action should take?

Many actions reviewed in Chapters 6 and 7 pertain to site or spot impacts observed by the manager. We have not recorded any attempt by managers to change regulations for the access of the area in order to mitigate local impacts. This may be justified by the consideration that visitors to parts of the area that are not under apparent stress should not be punished for problems elsewhere. However, in view of increasing numbers of visitors and an increasing rate of participation, such regulations at the area level certainly deserve more attention. Particularly for the Biesbosch area only few general restrictions are imposed, thus enabling a variety of visitor types to come to the area. It may be questioned if this is in accordance with the general aims as stated for National Parks in the Netherlands.

Apart from these considerations, zoning by fences, prohibitions etc. is certainly useful. However, if natural features of the landscape (helped by some ecological management) would be used as zoning instruments, the result might be as effective, but it would be less annoying and more cost-effective. Again, IMR relationships research may provide valuable answers.

Are actions accepted by users and policy-makers?

We have dealt with this question in the section on "Perception of multiple use" (see above). We emphasize that any regulating action will evoke negative reactions by the users involved; in some cases (as has been observed in the Biesbosch) users will ostentatively protest. Therefore the role of information about the area, its use and the management actions needed to ensure continuity of that use, cannot be overestimated. Management science can help to provide such information.

We also stress the importance of the possible choice by the manager for "doing nothing". If the manager has developed a good monitoring system for receiving signals that tell him to act or not to act, he has many possibilities to wait and see. Particularly in the cases studied, where a nearby or soon depletion of the resource is not at issue, there is no reason for risk-averting management, as it would be difficult to explain this in acceptable terms to the users involved.

How effective are actions?

The majority of management actions reviewed is effective in terms of regulation of use. Zoning is the best example, as shown in both the NHDR and the Biesbosch case. In a number of cases the "no action" option has not led to alarming deterioration of resource ecosystem performance although local damage has been assessed (tourist spots, horse-riding, dewberries).

Yet any decision by the manager about taking action should be based on data from monitoring systems regarding both multiple use and resource performance. If this basis is secured and provides actual information, effectiveness of actions can be optimized. Again we advocate the use of IMR relationships as a tool in management decision-making. Only by measuring impacts of management actions on both use intensities and resource performance the manager is able to assess effectiveness. Once a monitoring system has been established, the use of it will probably justify its costs.

In most cases of multiple use of natural resources, we are still far from effective management in the sense of preserving resource supply by wise management of use (and not, as some people think, wise use, because this attitude of users is difficult to envisage in multiple use cases). The management tools indicated in this and many other books may, however, advance this effectiveness.

APPENDIX A LIST OF SCIENTIFIC AND ENGLISH NAMES OF BIRDS AND PLANTS

Names of bird species referred to (after SOVON, 1987)

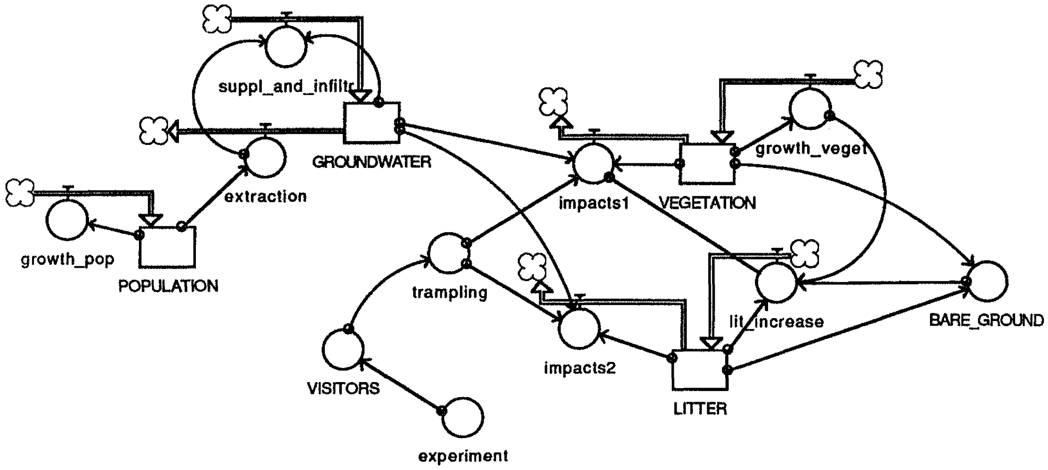
Acrocephalus palustris	Marsh Warbler
Acrocephalus scirpaceus	Reed Warbler
Alcedo atthis	Kingfisher
Anas clypeata	Shoveler
Anas platyrhynchos	Mallard
Anas querquedula	Garganey
Anas strepera	Gadwall
Anser anser	Greylag Goose
Ardea purpurea	Purple Heron
Aythya fuligula	Tufted Duck
Botaurus stellaris	Bittern
Cyanosylvia svecica	Bluethroat
Egretta garzetta	Little Egret
Emberiza schoeniclus	Reed Bunting
Ixobrychus minutus	Little Bittern
Locustella luscinioides	Savi's Warbler
Numenius arquata	Curlew
Nycticorax nycticorax	Night Heron
Oenanthe oenanthe	Wheatear
Pandion haliaetus	Osprey
Phalacrocorax carbo	Cormorant
Phasianus colchicus	Pheasant
Phylloscopus collybita	Chiffchaff
Phylloscopus trochilus	Willow Warbler
Platalea leucorrhodia	Spoonbill
Podiceps cristatus	Great Crested Grebe
Porzana porzana	Spotted Crake
Prunella modularis	Dunnock
Recurvirostra avocetta	Avocet
Riparia riparia	Sand Martin
Saxicola rubetra	Whinchat
Sterna hirundo	Common Tern
Sylvia borin	Garden Warbler
Sylvia curruca	Lesser Whitethroat
Troglodytes troglodytes	Wren

Names of plant genera and species referred to (after Van der Meijden *et al.*, 1983, and Clapham *et al.*, 1987)

Ammophila arenaria	Marram Grass
Angelica archangelica	Garden Angelica
Calamagrostis epigejos	Wood Small-reed, Bushgrass
Chamerion angustifolium	Rosebay Willow-herb, Fireweed
Corynephorus canescens	Grey Hair-grass
Dactylis glomerata	Cock's-foot
Elymus farctus	Sand Couch-grass
Empetrum nigrum	Crowberry
Erodium sp. (cicutarium)	Stork's-bill
Festuca rubra	Red fescue
Galium sp.	Bedstraw
G. mollugo	Hedge Bedstraw
G. verum	Lady's Bedstraw
Glechoma hederacea	Ground-ivy
Hippophae rhamnoides	Sea-buckthorn
Impatiens glandulifera	Indian Balsam
Koeleria cristata	Crested Hair-grass
Phragmites communis	Common Reed
Pinus nigra ssp. nigra	Austrian Pine
Plantago major	Great Plantain
Poa annua	Annual Meadow-grass
P. trivialis	Rough Meadow-grass
Polygonum amphibium	Amphibious Bistort
Polypodium vulgare	Polypody
Ranunculus repens	Buttercup
Rubus caesius	Dewberry
Salix repens	Creeping Willow
Scirpus lacustris	Bulrush
Senecio sp.	Ragwort
Taraxacum spec.	Dandelion
Urtica dioica	Common nettle, Stinging Nettle

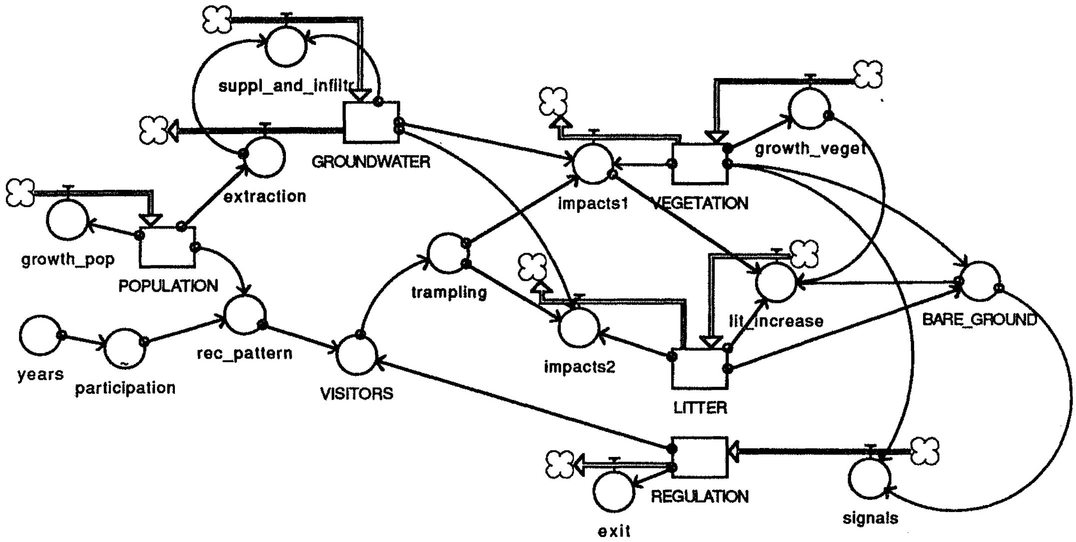
APPENDIX B SPECIFICATIONS OF SIMULATION MODELS

1. STELLA model for impacts of experimental trampling



- ☐ GROUNDWATER = GROUNDWATER + suppl_and_infiltr - extraction
  INIT(GROUNDWATER) = 500
- ☐ LITTER = LITTER - impacts2 + lit_increase
  INIT(LITTER) = 35
- ☐ POPULATION = POPULATION + growth_pop
  INIT(POPULATION) = 1000
- ☐ VEGETATION = VEGETATION + growth_veget - impacts1
  INIT(VEGETATION) =60
- ○ BARE_GROUND = 100-VEGETATION-LITTER
- ○ experiment = IF TIME >3 THEN 0 ELSE 1
- ○ extraction = POPULATION/1000*50+POPULATION/1000*RANDOM*2.5
- ○ growth_pop = POPULATION*.004+POPULATION*.01*RANDOM
- ○ growth_veget =(3*VEGETATION+.1*VEGETATION*VEGETATION)*(1-VEGETATION/(56+RANDOM*8))/7
- ○ impacts1 =500/GROUNDWATER*LOGN(trampling*trampling+2.72)*VEGETATION/60*3.5
- ○ impacts2 = 500/GROUNDWATER*LOGN(trampling*trampling+2.72)*LITTER/35*.3
- ○ lit_increase = (impacts1-growth_veget*LITTER/(LITTER+BARE_GROUND))*.7
- ○ suppl_and_infiltr = IF GROUNDWATER<450 THEN (extraction*.9+RANDOM*extraction*.15)*1.05 ELSE extraction*.9+RANDOM*extraction*.15
- ○ trampling = VISITORS*.1
- ○ VISITORS = 360*experiment

2. STELLA model for multiple use (recreation, water-supply, conservation) impacts and management



☐ GROUNDWATER = GROUNDWATER + suppl_and_infiltr - extraction
INIT(GROUNDWATER) = 500

☐ LITTER = LITTER - impacts2 + lit_increase
INIT(LITTER) = 50

☐ POPULATION = POPULATION + growth_pop
INIT(POPULATION) = 1000

☐ REGULATION = REGULATION + signals - exit
INIT(REGULATION) = 0

☐ VEGETATION = VEGETATION + growth_veget - impacts1
INIT(VEGETATION) =40

○ BARE_GROUND = 100-VEGETATION-LITTER

○ exit = IF REGULATION>0 THEN .5 ELSE 0

○ extraction = POPULATION/1000*50+POPULATION/1000*RANDOM*2.5

○ growth_pop = POPULATION*.004+POPULATION*.01*RANDOM

○ growth_veget =(3*VEGETATION+.1*VEGETATION*VEGETATION)*(1-VEGETATION/(56+RANDOM*8))/7

○ impacts1 =500/GROUNDWATER*LOGN(trampling*trampling+2.72)*VEGETATION/60*3.5

○ impacts2 = 500/GROUNDWATER*LOGN(trampling*trampling+2.72)*LITTER/35*.3

○ lit_increase = (impacts1-growth_veget*LITTER/(LITTER+BARE_GROUND))*.7

○ rec_pattern = (POPULATION*.2+POPULATION*.02*RANDOM)*participation/100

○ signals = IF 36/VEGETATION*BARE_GROUND/16>1.2 THEN 1 ELSE 0

○ suppl_and_infiltr = IF GROUNDWATER<450 THEN (extraction*.9+RANDOM*extraction*.15)*1.05 ELSE extraction*.9+RANDOM*extraction*.15

○ trampling = VISITORS*.095+.01*VISITORS*RANDOM

○ VISITORS = IF REGULATION >0 THEN rec_pattern*.55 ELSE rec_pattern

○ years = TIME

⊘ participation = graph(years)

1960 -> 100	1984 -> 144
1964 -> 103	1988 -> 146
1968 -> 108	1992 -> 148
1972 -> 117	1996 -> 149
1976 -> 129	2000 -> 150
1980 -> 140	

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SAMENVATTING

Natuurgebieden vormen een belangrijk deel van het totaal aan natuurlijke hulpbronnen. Ze kunnen grondstoffen voor de economie leveren, maar ook kunnen ze worden gebruikt voor recreatie, voor natuurstudie etc. Ze hebben een esthetische betekenis, en de dieren en planten die er leven hebben ook recht op een bestaan. Natuurgebieden komen onder steeds zwaardere druk te staan omdat de totale vraag naar gebruik ervan het vermogen om aan die vraag te voldoen overstijgt.
Natuurbehoud is feitelijk een gebruiksvorm van de ongebouwde omgeving, naast andere gebruiksvormen. Gebruik van een gebied voor natuurbehoud houdt echter meestal in dat andere gebruiksvormen niet, of in bescheiden mate, toelaatbaar zijn. Voorbeelden daarvan zijn de Nationale Parken waarin natuurbehoud èn de gelegenheid om van de aanwezige natuur te genieten (natuurgerichte openluchtrecreatie dus) de hoofdgebruiksvormen zijn. Andere gebruiksvormen passen hier niet of nauwelijks bij.

Dit boek gaat over het *beheer* van natuurgebieden en hun natuurlijke hulpbronnen die op verscheidene manieren ("meervoudig") worden gebruikt. Er is veel bekend over beheer en gebruik van natuurgebieden, maar de informatie over meervoudig gebruik is schaars, zeker als het gaat om de wisselwerking tussen verschillende gebruiksvormen en de invloed daarvan op de ecosystemen van een natuurgebied. Dat geldt ook voor het inzicht in de consequenties (voor het gebruik en voor het gebied) van eventuele alternatieve beheersmaatregelen.
De belangrijkste besproken gebruiksvorm is openluchtrecreatie; deze wordt in verband gebracht met de gebruiksvormen natuurbehoud, waterwinning en zeewering. Deze gebruiksvormen betekenen elders vaak "medegebruik", naast de dominante Nederlandse landgebruiksvormen als landbouw, veeteelt, wonen etc. Voorbeelden worden vooral ontleend aan eigen onderzoek in twee gebieden, het Noordhollands Duinreservaat (een potentieel Nationaal Park) en de Biesbosch (een NP in oprichting). De Hoofdstukken 2, 3 en 4 geven een algemene analyse van meervoudig gebruik, draagkracht van ecosystemen en beheer van meervoudig gebruikte gebieden. De Hoofdstukken 5, 6 en 7 gaan in op specifieke beheersvraagstukken in de genoemde gebieden. Enige slotopmerkingen zijn opgenomen in Hoofdstuk 8.

Meervoudig gebruik van natuurlijke hulpbronnen

Bijna elk gebied in Nederland wordt op verscheidene manieren gebruikt. In veel gevallen is dat meervoudig gebruik historisch gegroeid. De onderlinge verhoudingen tussen gebruiksvormen veranderen in de tijd. Vier hoofdvormen van wisselwerking tussen gebruiksvormen worden onderscheiden: "onverschilligheid", "samenwerking", "wedijver" en "uitsluiting". Bij toenemende gebruiksintensiteit komt het accent steeds meer op (gedeeltelijke) uitsluiting van gebruiksvormen te liggen.
Meestal is de totale vraag van gebruikerszijde groter dan een natuurgebied kan aanbieden; er is dus sprake van schaarste van de goederen en diensten die door het gebied worden geleverd. In het geval van meervoudig gebruik van natuurgebieden, die overigens dikwijls gemeenschapseigendom

zijn, zijn meestal drie categorieën goederen en diensten in het spel. Individuele goederen kunnen op de markt worden verhandeld en hebben een prijs. Collectieve goederen en diensten kunnen niet op de markt worden verhandeld. Een vuurtoren als lichtbaken voor schepen is een standaardvoorbeeld. "Common property resources" zijn hulpbronnen in gemeenschappelijk eigendom waarbij sprake is van competitie tussen gebruikers. Omdat slechts de individuele goederen een prijs hebben, zijn de waarden van de verschillende goederen en diensten moeilijk te vergelijken, zodat een berekening van maximaal rendement in guldens niet mogelijk is.
Via de berekening van "schaduwprijzen" voor goederen is aan dit probleem wel iets te doen, al leveren verschillende methoden ook verschillende uitkomsten op. Een bijkomend probleem is de vraag of er sprake is van een "voorraad-hulpbron" (bijvoorbeeld bomen, zonne-energie) die zichzelf weer aanvult of nooit opraakt. Vele biotische hulpbronnen kunnen blijven leveren zolang ze niet te snel en te veel worden gebruikt.
Goederen en diensten kunnen worden onttrokken aan de hulpbron maar ook niet-onttrekkend gebruik is mogelijk: een voorbeeld is openluchtrecreatie. Niet-onttrekkend gebruik lijkt duurzamer; als dat echter te intensief wordt (openluchtrecreatie is weer een voorbeeld), kan er stress optreden in de ecosystemen die de hulpbronnen omvatten.

Gezien het bovenstaande is het moeilijk om te beoordelen welke configuratie van meervoudig gebruik van een natuurgebied relatief het meeste recht doet aan de totale maatschappelijke vraag in verhouding tot de beschikbaarheid van de hulpbronnen op termijn. Voor een dergelijk oordeel is in elk geval ook informatie nodig over de gebruikspatronen.
Recreatieve gebruikspatronen van een natuurgebied hangen af van karakteristieken en voorkeuren van gebruikers, van afstanden tot bevolkingscentra, van het aanbod van alternatieve gebieden en van de eigenschappen van het gebied zelf. Bezoekersaantallen variëren in de tijd en worden door het weer beïnvloed. De verdeling van bezoekers over een terrein hangt af van motieven, terreinkennis en de inrichting van het terrein. Gedetailleerde recreatiepatronen zijn niet gemakkelijk te verklaren (al zijn ze op zich redelijk te meten) en te voorspellen.
De meeste andere gebruiksvormen van natuurgebieden zijn goed meetbaar, verklaarbaar en voorspelbaar. Dit geldt uiteraard slechts zolang de doelstellingen voor gebruik ongewijzigd blijven.

Draagkracht van hulpbronnen

Bij het beoordelen en het reguleren van meervoudig gebruik van hulpbronnen, c.q. natuurgebieden, is het belangrijk om na te gaan hoeveel gebruik mogelijk is zonder de duurzaamheid van het gebruik te verminderen. Die mate van gebruik wordt ook wel draagkracht ("carrying capacity") genoemd. In dit boek gaat het vooral om locale draagkracht, namelijk van één gebied of een deel daarvan.
In de ecologie houdt draagkracht een maximale populatie-omvang in. Meervoudig gebruik van een natuurgebied is echter lang niet altijd maximaal. In de ecologische notie krimpt de populatie als de draagkracht wordt overschreden; bij meervoudig gebruik krimpt dit gebruik pas als het gebied geheel onbruikbaar is geworden.
Draagkracht als concept heeft veel reacties opgeroepen. Inzake openlucht-

recreatie in natuurgebieden is het concept nagenoeg afgeschreven als hulpmiddel bij beheersmaatregelen. Toch is het zinvol om nader te bezien in hoeverre dit juist is.
Draagkracht is vaak een zaak van evenwicht tussen "groei" van de hulpbron (in geval van biota) en consumptie ervan. De relatie tussen consumptie en krimp van de hulpbron noemen we stimulus-respons-relaties, de "groei" noemen we herstel.

Stimulus-respons-relaties geven de gevolgen van gebruik van een hulpbron (als onderdeel van een natuurgebied) aan. In geval van meervoudig gebruik zijn zulke relaties gecompliceerd, terwijl ook voortdurend gebruik extra effecten kan sorteren. Voorbeelden van SR-relaties voor experimentele betreding van duinecosystemen geven aan dat reeds een geringe stimulus een grote respons veroorzaakt. Met name geldt dit voor de hoogte, bedekking en volume van planten en voor aantallen ongewervelde dieren. In mindere mate wordt het voorkomen van soorten planten en dieren beïnvloed. De aard van de respons verschilt per plante- of diersoort en per locatie. Het selecteren en representatief meten van responsvariabelen is dan ook niet eenvoudig.

Herstel is het vermogen van een hulpbron of een ecosysteem om na verstoring in de oorspronkelijke toestand terug te keren; de benodigde tijd wordt aangeduid als herstelduur. Als deze periode zeer lang of oneindig is, wordt gesproken van onomkeerbare uitputting van de hulpbron. Het herstel van plante- en diersoorten hangt af van de eigen "groei"capaciteit en van de eventueel gewijzigde milieu-omstandigheden. Een door herstel te bereiken optimum kan afwijken van de uitgangssituatie.
Voorbeelden van herstel in duinecosystemen na experimentele betreding geven aan dat de meeste waargenomen bodem-, plante- en diervariabelen in eerste instantie vlot lijken te herstellen doch dat de uitgangssituatie dikwijls pas na enige jaren weer wordt bereikt. In geval van zware betreding kan de herstelduur oplopen tot tien jaar of langer. Sommige soorten profiteren evenwel van de gewijzigde omstandigheden.

Stimulus-respons-relaties en herstelduren zijn complementair in de relatie tussen gebruik en reactie daarop van hulpbronnen. De uitkomsten van de betredingsexperimenten kunnen in eenvoudige simulatiemodellen worden ingevoerd, waardoor inzicht kan worden verkregen in zulke gebruik-reactie-relaties. Reeds in dergelijke relatief eenvoudige situaties is het moeilijk om het draagkrachtsbegrip operationeel te maken. In situaties met meervoudig gebruik van hulpbronnen lijkt een operationalisering een illusie. Toch kunnen SR-relaties en hersteldur worden gebruikt voor het formuleren van doelstellingen, het schatten van duurzame gebruiksintensiteiten en het beoordelen van waarnemingsresultaten.

Beheer van meervoudig gebruik van hulpbronnen

Beheer van meervoudig gebruikte natuurgebieden heeft betrekking op het gebruik en op de duurzame beschikbaarheid van hulpbronnen daartoe. Het beheer dient in Nederland plaats te vinden in overeenstemming met plannen voor ruimtelijke ordening en andere overheidsplannen. Binnen deze (en de wettelijke) speelruimte moet de beheerder gebruiksmogelijkheden binnen de

randvoorwaarde van duurzaamheid optimaliseren. Voor Nationale Parken als bijzonder geval geldt dat natuurbehoud en natuurgerichte recreatie moeten worden geoptimaliseerd.
Het beheer wordt voorts beperkt door de ecologische hoedanigheden van het betreffende gebied en door wisselwerkingen tussen gebruiksmogelijkheden. Andere beperkingen betreffen het budget en de beschikbare informatie over het bovengenoemde.

Instrumenten voor het beheer van meervoudig gebruik en van de hulpbron(nen) kunnen in drie categorieën worden ondergebracht. *Beheer van actueel gebruik* door recreanten betreft vooral regulering van de toegankelijkheid (via fysieke begrenzing, entreegelden en toegangsvoorwaarden) van het gebied, zonering (via infrastructuur, locatie van voorzieningen en locale beperkingen) binnen het gebied, en voorlichting (via informatieborden, bezoekerscentra en locale toeristenorganisaties) over het gebied en het gewenste gebruik ervan.
Ook de *"uitwendige" situatie* van een gebied (alles buiten een gebied dat het gebruik of het gebied zelf beïnvloedt) kan worden beïnvloed doch de beheerder heeft er geen exclusieve zeggenschap over. Het gaat hier vooral om de structuur van de regio rondom het gebied (infrastructuur, alternatieven, voorzieningen), om boven-locale voorlichting over (voorwaarden voor) gebruik van het gebied en om verontreinigings- en verstoringsbronnen buiten het gebied.
De derde categorie betreft de *ecologie van het gebied* (en de hulpbronnen daarbinnen). Natuurbehoud en -ontwikkeling vergen soms een ecologisch beheer dat ander gebruik bemoeilijkt. In geval van meervoudig gebruik is, ter voorkoming van uitsluiting, een terughoudend ecologisch beheer nodig dat geen der gebruiksvormen bevordert of belemmert. Vaak is "niets doen" (naast de genoemde instrumenten) een goede mogelijkheid.

De *doeltreffendheid* van beheer wordt meestal beoordeeld in relatie tot de kosten en baten ervan. Meervoudig gebruik van natuurlijke hulpbronnen is slechts gedeeltelijk in geld te waarderen. Doelen worden lang niet altijd kwantitatief gesteld en interpretatie van veranderingen in relatie tot doelstellingen is dikwijls niet eenvoudig. Door conflicterende doelstellingen worden de meeste gebruiksvormen sub-optimaal gerealiseerd. Hieraan kan wat worden gedaan door het hanteren van een hiërarchie van doelstellingen, consensusprocedures voor gebruikers, zonering van gebruiksvormen of op verruiming van gebruiksmogelijkheden gericht ecologisch beheer.
Doeltreffendheid van maatregelen valt af te meten aan veranderingen in gebruik en in de toestand van het gebied. Geïntegreerde maatregel-effectrelaties (GME) beschrijven zulke ketens van beheersmaatregelen, gebruik en reactie van de hulpbron. GME-relaties kunnen gebruikspatronen, SR-relaties, herstelduur, beheer van gebruik en van het gebied omvatten, onder meer via eenvoudige simulatiemodellen. Deze verschaffen vooral inzicht in de mogelijkheden van beheer in gecompliceerde situaties.
Beoordeling van doeltreffendheid omvat ook externe invloeden van beheersmaatregelen. Het gaat daarbij vooral om de gevolgen van gebruiksbeperkingen of -verruimingen op de regionale schaal.
Er moet dus veel worden gemeten om doeltreffendheid te kunnen beoordelen. Naast selectie van variabelen en meetproblemen vormt het formuleren van

beoordelingscriteria per variabele een groot probleem.

"Met de beide benen op de grond"

De analyses van meervoudig gebruik van natuurlijke hulpbronnen en het beheer terzake roepen zoveel vragen en mogelijkheden op, dat een toetsing aan praktijksituaties verhelderend kan werken. Deze betreffen het gebruik en het beheer van het Noordhollands Duinreservaat (NHD) resp. het Nationale Park (in oprichting) De Biesbosch. In beide gebieden is natuurbehoud de belangrijkste gebruiksvorm. Andere gebruiksvormen zijn uitdrukkelijk toegestaan (recreatie; in het NHD waterwinning en zeewering), worden in bescheiden mate getolereerd of worden buiten het gebied gehouden doch vinden geografisch gezien binnen het gebied plaats (waterberging en landbouw in de Biesbosch). Het natuurbeheer is gericht op ontwikkeling; in het recreatiebeheer worden vooral zonering en eenvoudige voorzieningen als instrumenten gehanteerd.
Drie thema's voor beheer worden nader besproken: natuurbeheer in het licht van de wisselwerkingen tussen natuurbehoud en andere gebruiksvormen; recreatiebeheer in het licht van de wisselwerkingen tussen recreatie en natuurbehoud, waterwinning en zeewering; waterwinning of -berging in het licht van wisselwerkingen met de genoemde gebruiksvormen.

Het Noordhollands Duinreservaat

In het NHD is in de afgelopen decennia het gebruik voor natuurbehoud, openluchtrecreatie en waterwinning veranderd. Deze veranderingen hebben niet tot evidente conflicten geleid, maar ze hebben - blijkens beheersnota's - wel de aandacht van het beheer.

Zonering van recreatie ten behoeve van natuurbehoud binnen het NHD als geheel is doeltreffend, gezien het intensieve gebruik van voorzieningen (wandelroutes, speelvelden, banken, uitzichtspunten) en het geringe aantal (9%) bezoekers dat - illegaal - de wegen en paden verlaat. Toch zijn er duidelijke effecten, zoals illegale paden met grote stukken kaal zand en een relatief klein vegetatievolume (doch met evenveel plantesoorten als daarbuiten).
Zonering van recreatie in deelgebieden en op specifieke plekken is vooral effectief als terreingedeelten worden omheind. Gedeeltelijke afsluiting is minder doeltreffend en er ontstaan nieuwe illegale paden. Het landschapsbeeld wordt echter minder verstoord. Het herstel van de vegetatie in afgesloten gebieden is niet spectaculair; sommige plantesoorten die karakteristiek zijn voor de omgeving van zeedorpen, verdwijnen.

Veranderingen in recreatief gebruik blijken uit enquêtes. De motieven om het NHD te bezoeken zijn tussen 1962 en 1983 sterk veranderd. Natuur, landschap, stilte en rust worden belangrijker, evenals mogelijkheden voor wandelen en fietsen. Frisse lucht, het "weg uit de stad"-motief en gezelligheidsmotieven worden minder belangrijk.
De aantallen bezoekers per jaar zijn sinds 1960 verdubbeld, maar het aandeel van de regelmatige bezoekers is sterk toegenomen. De belangrijkste oorzaken van hinder in het gebied zijn racefietsers, de aanwezigheid van

"teveel" bezoekers, de verplichte toegangskaart en het aanlijngebod voor de hond. Omheiningen en het verbod om wegen en paden te verlaten worden nauwelijks als hinderlijk beschouwd.

"Littekens in het landschap" zijn ruiterpaden. Deze worden na aanleg zeer snel kaal door de betreding door paarden. In geaccidenteerd terrein kan erosie plaatsvinden. Vele plantesoorten verdwijnen. Ook vlak naast een ruiterpad neemt de bedekking met planten af; sommige plantesoorten profiteren van deze omstandigheden. Na afsluiting van een ruiterpad herstelt de vegetatie zich langzaam. Na meer dan tien jaar is een afgesloten ruiterpad nog zichtbaar, al hebben de meeste soorten zich dan goed hersteld. Het aanschuiven van de padranden naar het pad als beheersmaatregel heeft geen positieve invloed op de snelheid van herstel.
Gezien deze conclusies moet het verleggen van ruiterpaden zoveel mogelijk worden beperkt. Nieuwe ruiterpaden zijn, gezien de huidige lage gebruiksintensiteit, niet nodig en zijn landschappelijk ook niet wenselijk.

Bramenpluk buiten de paden is per traditie toegestaan tussen 10 augustus en 10 september. Dit levert schade aan het terrein op: platgetrapte planten, kaal zand en nieuwe illegale paadjes. Het niet (duidelijk) beïnvloede oppervlak van de onderzochte locaties is echter groot. Het aantal aanwezige plantesoorten wordt nauwelijks beïnvloed. Het herstel in het voorjaar verloopt niet eenduidig, maar bezien over een langere periode (acht jaar) valt geen duidelijke achteruitgang te constateren. Andere mogelijke negatieve invloeden van de bramenpluk betreffen het doodtrappen van kleine ongewervelde dieren en het verstoren van vogels. Voor negatieve invloeden op waterwingebieden, op de zeewering en op de beleving van natuur en landschap zijn geen aanwijzingen gevonden.
Bramen plukken blijkt een favoriete bezigheid van vele bezoekers. Velen houden er ook gratis consumptiegoederen (jam) aan over. Afschaffing van de bramenpluk zou kunnen leiden tot negatieve publiciteit en politieke oppositie, terwijl de kosten van het toezicht zouden toenemen.

Waterwinning. De twee waterinfiltratiegebieden in het NHD beslaan tien procent van het oppervlak van het open (niet met bos begroeide) duinlandschap. Een ervan is toegankelijk voor recreanten en wordt ook frequent bezocht. Wateronttrekking heeft geleid tot het verdwijnen of achteruitgaan van een groot aantal vochtminnende plantesoorten. In en rondom de infiltratiegebieden is de vegetatie veranderd door de inlaat van voedselrijk en verontreinigd water. Dit water is ondergronds over een aanzienlijk oppervlak verspreid.
Het beheer tracht thans om met natuurtechnische maatregelen de terugkeer van vochtminnende soorten te bevorderen. Voorts zal in de toekomst diepte-infiltratie worden beproefd teneinde de beïnvloeding van de vegetatie door infiltratiewater niet groter te doen worden.

Deze voorbeelden duiden aan dat waterwinning en zeewering nauwelijks worden beïnvloed of uitgesloten door andere gebruiksvormen. Recreatie wordt plaatselijk beperkt of uitgesloten, en natuurbehoud lijkt een sluitpost behalve in locaties waar deze gebruiksvorm op de eerste plaats komt. Toch is geen enkele gebruiksvorm zo dominant dat deze de andere goeddeels onmogelijk maakt. Deze configuratie van meervoudig gebruik lijkt redelijk

stabiel en duurzaam; het gebied "kan dit aan". Een spoedige recreatieve ontwikkeling wordt niet verwacht en het natuurbehoud wordt via natuurontwikkelingsmaatregelen versterkt.
Op langere termijn zal de bevolkingsgroei tot een grotere vraag naar recreatiemogelijkheden en naar drinkwater leiden. Hiertoe zouden randgebieden van het NHD kunnen worden ingericht en de diepte-infiltratie zou kunnen toenemen. Een gedeeltelijke uitsluiting van recreatie en van waterwinning zou noodzakelijk kunnen zijn.
Het beheer van het meervoudig gebruik wordt belemmerd door eisen vanuit de waterwinning, de zeeweringsfunctie en de recreatie (bramenpluk). Daarnaast kunnen de kosten belemmerend (gaan) werken, evenals het gebrek aan informatie over de relaties tussen beheer, gebruiksvormen en terreinomstandigheden (geïntegreerde maatregel-effect-relaties).

Het Nationale Park "De Biesbosch"

In de Biesbosch is een configuratie van meervoudig gebruik ontstaan, waarin natuurbehoud, recreatie en waterberging (voor drinkwaterdoeleinden) elkaar beconcurreren en uitsluiten. De status van Nationaal Park stelt hoge eisen aan het toekomstige beheer, in termen van verandering van het aandeel van deze gebruiksvormen in het totale gebruik.

De huidige zonering ten behoeve van het natuurbehoud betreft, afgezien van enige gesloten natuurreservaten, vooral het beperken van varen en aanleggen met kajuitmotorjachten. Deze zonering werkt in het algemeen goed, al gaan recreanten aan wal op vele plaatsen waar dat niet is toegestaan. De recreatie is relatief geconcentreerd op de aanwezige (eenvoudige) voorzieningen en wordt ook gezoneerd door natuurlijke beperkingen zoals vaardieptes.
Een verdergaande beperking van de vaarmogelijkheden lijkt minder zinvol (onder meer gezien de handhavingsproblematiek) dan te pogen om de recreatie verder te concentreren middels aanvullende voorzieningen. Voorts wordt aan voorlichting en educatie een belangrijke rol toegedacht.
Uit een scenario-analyse tot 1995 blijkt dat het aantal ligplaatsen in jachthavens rond de Biesbosch een cruciale variabele is bij het beïnvloeden van de totale bezoekers aantallen. Voorts blijkt dat de aanleg van de Aakvlaai (een op recreatie toegesneden uitbreiding van de Biesbosch) de bezoekersaantallen in het eigenlijke Nationale Park gedurende lange tijd op gelijk niveau helpt te houden.

Perceptie van (veranderingen in) recreatief gebruik. Uit een in 1983 gehouden enquête blijkt dat driekwart van de bezoekende boten een ligplaats in de regio heeft, en dat de helft minstens een keer per week naar de Biesbosch komt. 70% van de respondenten wil niet nog meer boten in de Biesbosch. Hinder wordt vooral ondervonden van snelle motorboten, waterskiën en plankzeilen. De kajuitmotorjachten hinderen 45% van de andere bootgebruikers. Vele respondenten vinden dat schade door recreatie aan de natuur niet aantoonbaar is, en denken dat recreatiegedrag in het geheel niet tot schade leidt. Landschap, stilte en natuur zijn belangrijke motieven om naar de Biesbosch te komen. Voorzieningen, sociale contacten en nabijheid zijn eveneens belangrijke motieven. Er is een duidelijke tweedeling te onderkennen in gebiedsgericht en voorzieningengericht gebruik.

Een eventuele verdringing van "veteranen" onder de Biesboschbezoekers door relatieve nieuwkomers (na 1975) kan niet worden aangetoond, al zijn er wel aanwijzingen voor. Met name uit het verschil in belangstelling voor voorzieningen blijkt het onderscheid in bezoeksmotief.

"Littekens in het landschap" zijn de recreatieplekjes: locaties op oevers waar de vegetatie niet de daar verwachte structuur en samenstelling vertoont, zulks als gevolg van recreatief gebruik (recreatieve voorzieningen vallen hierbuiten). De meeste recreatieplekjes zijn in grienden (wilgenvegetaties) langs vrij toegankelijke kreken te vinden. Meestal hebben ze een aanlegplek, een aantal paden en enige stookplaatsen, vaak ook een duidelijke verblijfsplek ("satelliet"). De lengte van de aanlegplek, het aantal stookplaatsen en het totale ruimtebeslag zijn positief gecorreleerd met het aantal liggende boten per 100 meter kreeklengte. Ook herstel van recreatieplekjes is - in geringe mate - waargenomen.
Met name in het recreatiescenario (zie boven) wordt locaal een aanzienlijke uitbreiding van het oppervlak aan recreatieplekjes verwacht. In het natuurscenario zouden zulke plekjes locaal verdwijnen, doch elders zouden er nieuwe bijkomen. In alle scenario's levert de aanleg van de Aakvlaai een vermindering van recreatieplekjes op.

Recreatie kan broedvogels verstoren en kan mogelijke broedvogelsoorten belemmeren om tot broeden te komen. In de Biesbosch is aangetoond dat het broedgedrag van IJsvogel en Fuut door recreatieve activiteiten wordt verstoord. Het is echter onduidelijk of deze verstoring ook het broedsucces en de populaties beïnvloedt.
Een negatieve invloed op aantallen broedvogels van recreatieve activiteiten kan slechts worden aangetoond als de steekproef vooral gebieden omvat die relatief veel worden bezocht. Met name voor de soorten Blauwborst, Snor en Fitis, en voor het totale aantal broedvogelsoorten lijken zulke verbanden aantoonbaar. In relatief stille gebieden blijken dichtheden van alle soorten vooral samen te hangen met kenmerken van het habitat.

Waterberging in de Biesbosch vindt plaats in drie drinkwaterreservoirs. Daarnaast is ruimte gereserveerd voor een vierde spaarbekken. Deze locaties zijn uitgesloten van het Nationale Park in oprichting. Toch valt het opnemen binnen de begrenzing van het NP te bepleiten wegens de huidige betekenis voor recreatie en natuurbehoud en de landschappelijke integriteit. De randen van de bekkens zouden niet als recreatievoorzieningen moeten worden ingericht; slechts eenvoudige, in het landschap te integreren, voorzieningen zouden moeten worden aangelegd.
Een claim op verwezenlijking van het vierde bekken kan worden gepareerd met nader onderzoek naar vraagtrends in relatie tot capaciteit. Ook zou dan nader onderzoek naar mogelijke locaties elders in de provincie (Zuid-Holland) dienen plaats te vinden. In geval van aanleg van het vierde bekken zou de omvang ervan moeten worden heroverwogen.

Uit de voorbeelden blijkt dat er thans een delicaat evenwicht tussen de diverse gebruiksvormen is. Waterberging wordt nauwelijks door de overige gebruiksvormen gehinderd; recreatie en natuurbehoud sluiten elkaar deels uit en worden beperkt door waterberging. Substantiële groei van een van

de gebruiksvormen zou dit evenwicht duidelijk verstoren. Daarnaast vormen waterbeheer, verkeer en vervoer, landbouw en water(bodem)verontreiniging evenzovele bedreigingen voor het huidige meervoudige gebruik en voor de status van Nationaal Park. Er is thans geen duidelijke reden om het vigerende beheer van het gebied te veranderen. Wel moet het jachthavenbeleid terughoudend zijn en dient de Aakvlaai met spoed te worden aangelegd. Op langere termijn zullen de groei van de vraag naar drinkwater en naar recreatiemogelijkheden problemen gaan opleveren. Oplossingen moeten buiten de grenzen van het NP worden gezocht.
Wat betreft de benodigde informatie is vooral periodieke waarneming van de recreatie-intensiteit (en de ruimtelijke verdeling ervan), van de ontwikkeling van recreatieplekjes en van broedvogeldichtheden gewenst. In geval van aanvullende beheersmaatregelen is het gewenst om geïntegreerde maatregel-effect-relaties te onderzoeken.

Besluit

Uit de voorbeelden van het NHD en de Biesbosch valt de algemene conclusie te trekken dat het beheer in staat is geweest om de gebruiksvormen recreatie, natuurbehoud, waterwinning en zeewering met elkaar in evenwicht te doen zijn zonder dat een bepaalde gebruiksvorm grotendeels uitgesloten of weggeconcurreerd wordt. Zonder beheer zou dit niet het geval zijn geweest. De huidige configuratie van meervoudig gebruik is voor alle gebruiksvormen niet optimaal. Toch leidt deze toestand slechts tot beperkte oppositie. Een verandering van de configuratie, bijvoorbeeld ten voordele van het natuurbehoud, zou mogelijk in het NHD en zeker in de Biesbosch problemen opleveren. Uit de voorbeelden valt niet af te leiden of een andere configuratie dichter bij een optimum van totaal "nut" (voor alle gebruikers samen) zou liggen.

In de veldstudies is gebleken dat de gebruiksvormen zeer verschillende invloeden uitoefenen op delen van de gebieden. Toch is er thans geen sprake van geleidelijke achteruitgang, ofwel het krimpen van het totaal aan hulpbronnen. De huidige gebruiksconfiguraties lijken duurzaam.
Stimulus-respons-relaties geven vooral inzicht in de relatieve kwetsbaarheden van aspecten van ecosystemen. Uit de herstelgegevens blijkt dat alleen onder extreme omstandigheden onomkeerbare veranderingen optreden. In zulke gevallen wordt de draagkracht duidelijk overschreden. Meestal treden deze beïnvloedingen locaal op, en kan over de draagkracht van het totale gebied of van ecosystemen geen uitspraak worden gedaan.

De meeste beheersmaatregelen zijn genomen op grond van mogelijke problemen in het meervoudig gebruik en niet na vaststelling daarvan. Vaak is "niets doen" echter beter dan (vermeende) risico's voorkomen. Geïntegreerde maatregel-effect-relaties kunnen de "timing" van maatregelen vergemakkelijken. GME-relaties kunnen ook nuttig zijn voor een keuze uit maatregelen, naast signalen vanuit de samenleving. Omgekeerd is voorlichting over beheersmaatregelen zeer belangrijk.
Voor een en ander is een goede gegevensbasis nodig. Deze kan tevens worden gebruikt om de doeltreffendheid van maatregelen te meten. Daaraan schort thans, zeker in het geval van meervoudig gebruik van natuurlijke hulpbronnen, nog wel het een en ander.